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BUSINESS STRATEGY IN THE MEXICAN FLAT GLASS INDUSTRY: USING TECHNOLOGY AS A SOURCE OF COMPETITIVE ADVANTAGE

by

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Submitted to the Alfred P. Sloan School of Management
and the School of Engineering
in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN THE MANAGEMENT OF TECHNOLOGY

at the
Massachusetts Institute of Technology
June 1995

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ABSTRACT

In today's business complexity and globalization of markets, management of technology can mean the difference between success and failure. Consequently it is very important to understand technology as a source for achieving and sustaining competitive advantage. In order to understand how technology plays this crucial role in the business strategy, the work presented in this thesis focuses on the appropriate diagnosis of the existing state of the technology utilization, and addresses the necessary changes through formulating a technology strategy for a real company.

The study is based in the analytical framework developed by Arnoldo C. Hax and Nicolas S. Majluf in 1991. Using this methodology, the mission of the business is defined; then the flat glass industry is analyzed to identify opportunities and threats. Finally, an internal scrutiny of competitors is performed in order to assess their strengths and weaknesses.

To formulate the technology strategy, I have defined the technological requirements implied in the business strategy, as well as identified the main sources of information needed to establish the strategic technology units (STUs). Then the technology environmental scan and the technology internal scrutiny are analyzed in order to define a set of action programs for the technology function as a source of competitive advantage.

To demonstrate its use and prove its effectiveness, this methodology has been applied to Vitro Vidrio Plano, a real Mexican flat glass company that is one of the core glass business of the Vitro Group in Mexico.

Thesis Supervisor: Arnoldo C. Hax
Title: Alfred P. Sloan Professor of Management

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ACKNOWLEDGMENTS

This thesis work is dedicated to my wonderful wife Maria Eugenia for her love, constant encouragement and unfailing help during this year. Also, to my adorable children Carlos Omar and Claudia Cecilia, for their understanding and the tremendous source of youth they continually convey to me, which has been my driving force. Without my family's dedication and love this thesis would never have come into existence.

One of the greatest privileges at the MIT is the opportunity to interact with some of the world's top scholars. I have been fortunate to meet two exceptional people, both willing to oversee my thesis work. Professor Arnoldo C. Hax agreed to be my thesis supervisor, his guidance, wisdom, and encouragement have been of crucial importance to me. I am deeply grateful for his continuous availability to me, his guidance and patience throughout the course of this work. I would also like to express my sincere thanks to Professor James M. Utterback, my thesis reader, for his valuable insights, support, and advice, particularly when I was insufficiently focused on selecting my topic. I also appreciate the help received from the Faculty and Administrative Staff of the MOT program during the year.

Finally, but not least, I am most thankful and indebted to Vitro Vidrio Plano for giving me the financial assistance and the opportunity to improve my personal growth and professional development throughout this difficult but enjoyable time at MIT.

INTRODUCTION

> ***"The better approach, I believe, is to accept uncertainty, try to understand it, and make it part of our reasoning. Uncertainty today is not just an occasional, temporary deviation from a reasonable predictability, it is a base structural feature of the business environment. The method used to think about and plan for the future must be made appropriate to a changed business environment."***
>
> ***Pierre Wack (1985)***

The intent of this thesis is to design, analyze, and develop a strategic plan for Vitro Flat Glass Division. Underlying this strategic plan is the framework developed by A.C.Hax and N.S.Majluf (1991) and their Formal Strategic Planning Process. The goal is to define the technological requirements of the business unit, and create a common understanding between top management and the technical function for establishing an effective link between business and technology strategy.

The key background for this analysis is the continuing introduction of new reflective products in the flat glass industry, and the need to respond to unexpected technological events, thereby moving the firm from the position of technology follower to that of technology innovator, as well as incremental improver.

Using the Hax-Majluf methodology, I will define the mission of the business. Then I will perform an environmental scan to assess the Mexican flat glass industry to identify opportunities and threats. Following that, I will carry out an internal scrutiny to assess the relative strengths and weaknesses of the firm. All this assessment is done using public information and based on my personal experience, with some internal but limited qualitative information. The results are the subjective judgment of the author.

After identifying the business strategy, I will develop a technology strategy that assures a proper linkage between the business and technology strategies. A final goal of this study is to produce a set of broad action programs which should enhance the company's current position and secure a long-term sustainable competitive advantage, as well as promote the internal capabilities of the company.

The thesis is structured as follows: Chapter 1 provides a review of the literature, the conceptual framework and its elements, and concepts used throughout the strategy formation process. Chapter 2 offers the key concepts and a broad assessment of the technology in the flat glass industry to understand some models applied in the dynamics of the innovation process, and its implications for developing the technology strategy. The business strategy, and how to create the linkage between business and technology strategy using the four elements of the framework: mission of the business, environmental scan, internal scrutiny and action programs is presented in Chapter 3. An environmental scan of the industry is developed utilizing two alternatives methods: Porter's model (1980) and the External Factors Analysis, considering only the market and technology as a critical external factors in order to construct a systematic profile of the flat glass industry. The process of developing a technology strategy is shown in Chapter 4, which begins to derive the technological requirements implied by the business strategy. Then it defines the strategic technical units and analyzes opportunities and threats as well as the technological strengths and weaknesses of the company. Finally, Chapter 5 presents some conclusions and reflections regarding the methodology applied and the analysis done for Vitro Vidrio Plano (VVP) in its glass manufacturing business unit.

CHAPTER ONE

LITERATURE OVERVIEW AND CONCEPTUAL FRAMEWORK

In today's complex business environment, management of technology can mean the difference between success and failure and, consequently, it is very important to understand the role technology plays as a critical factor for achieving and sustaining competitive advantage. Managers, technical people, and researchers alike need effective ways to conceptualize and develop technology strategies. In order to define these methods, this chapter briefly describes the basic concepts and framework that are used throughout the thesis, then goes on to briefly describe the basic strategic functional unit which is key for formulating an effective technology strategy.

1.1 STRATEGY CONCEPTS AND THE STRATEGY FORMATION PROCESS

First I will examine the application of the methodology based on the framework suggested by Hax and Majluf (1991) in order to develop a technology strategy linked coherently with:

- business and corporate strategy,
- the literature review about concepts,
- basic elements of the strategy formation process,
- the framework developed by the above authors,
- an overview of previous studies done in this direction, and
- the results obtained from the implementation.

Then I made an overall assessment of the effectiveness of this methodology to assure a proper linkage between business and functional technology strategies. On the other hand, and even more important is how the methodology helps technical and nontechnical executives, to discuss technology strategy and develop a common

understanding of technology opportunities and threats and the company's strengths and weaknesses among people who have such different backgrounds. Moreover, it helps to create an agreed plan of actions in which all the organizational functions acknowledge their contributions as well as their needs in achieving the final goal of the corporation: "to increase long-term value for the shareholders". Using this method of communication and integration, managers and R&D managers work as partners to share and pool their insights in deciding what to do, why and when. In so doing, they take account of the needs of each business and of the corporation, and overcome the general trend to regard R&D as a "black box" or "ivory tower" only loosely connected to the rest of the company.

In his macroeconomic evaluation of the contribution of R&D to corporate profitability, Bruce Old (1982) demonstrated a strong positive relationship between long-term profitability and the proportion of cash flow that a company is willing to put at risk in R&D activities and in the productive capital investment that ensues. Although few will dispute his conclusion, the issue facing individual companies is not macroeconomics; it is less how much to spend on R&D and more how to spend allocated resources well. In truth, general management today believes that R&D planning is too important to be left solely to researchers as a secondary goal.

Another pressure necessitating more effective R&D is the modern competitive environment in which the rapid and sustained introduction of high-quality, innovative, cost-effective new products has become the name of the game. Strategically correct R&D goals will pay off the investment; strategically incorrect goals will waste scarce resources and even worse unrecoverable time. Ultimately, this means an era where, corporate, business, and R&D managers work as partners to establish overall R&D strategies that are tightly linked with business and corporate strategies and vision, and that focus on providing value to customers and shareholders in perpetuity[1]. As A.

[1]For a further discussion on the matter, the reader is referred to: Roussel, Saad, and Erickson, Third Generation R&D. Arthur D. Little, Inc. Boston, MA: Harvard Business School Press, 1991.

Morita, chairman and CEO of Sony, writes: *"technological management will be the key to success for companies anywhere in the world in the coming years"*.

In the successful management of the corporation, a trade-off between the inherent uncertainty of technology and the potential strategic benefits of technology is unavoidable. The value of good strategy is that it provides a shield against competition, ensures a measure of certainty, and allows an organization to create effective approaches to the needs of the marketplace. Technology is one of the key activities which promise such benefits.

The organizational costs of employing technology strategy within corporate and business strategies are accompanied by the need to cope with an added measure of uncertainty and disruption. It also means reconsidering the traditional planning process and a carefully integrating the paradigms of the strategists with the specialized jargon of the technologists. The key premise here is the idea that a well-understood joint position on the nature of technology and the nature of orthodox strategy can lead to an effective technology strategy process.

There have been numerous academic contributions that help us understand how to analyze technological developments, how to manage technology competitively and how to analyze the process and sources of innovation:

- Porter's concept of industry and competitor analysis (1980),
- the role of technological evolution and relationship between product and process innovation (Abernathy and Utterback, 1978; Utterback and Kim, 1986; Tushman and Anderson, 1986; Henderson and Clark, 1990; Montrey and Utterback, 1990; Afuah and Bahram, 1993),
- von Hippel's findings regarding the sources of innovation (1988),
- Allen's theory about flow of technological information and gatekeeper concept (1977),
- the strategic management of technology and innovation (White, 1988; Gattiker and Larwood, 1988; Edosowman, 1989; Steele, 1989),

- the concept of core competence and core capabilities (Prahalad and Hamel, 1990; Schoemaker, 1992; Meyer and Utterback 1993).

However few authors have developed practical methodologies and/or a strategic plan that integrates technology into the business strategy of the firm. This is not to say that technology is altogether absent from strategic plans of most manufacturing companies, but in general it appears in a fragmented piece of other functional strategies such as marketing, manufacturing, and engineering.

Definitions of Strategy

It is important to focus upon how the definitions employed to describe strategy clearly alter the types of decisions or alternatives taken by the firm to formulate and implement strategy. The wide variety of definitions illustrates an evolving understanding as various authors engage in thoughtful presentations of their explorations, and most of them seem to have emphasized a different perspective, providing only a single dimension of this fairly complex concept. For Example:

Steven Brandt (1981) establish a definition in a text that focuses on emerging corporations: *"Strategy is a summary statement of how objectives will be pursued."*

George Steiner (1969) suggests that: *"Strategic managerial planning is a philosophy, a process, a structure of plans which deal with the futurity of current decisions."*

John Grant & William King (1982) defines the concept as: *"A strategy is a timed sequence of internally consistent and conditional resource allocation decisions that are designed to fulfill an organization's objectives."*

Richard Vancil and Peter Lorange (1977) use another definition: *"Strategy is a conceptualization of long-term objectives, broad constraints and near term plans set by the executive and currently in operation."*

Michael Porter's definition (1980) includes goal formulation and an analytical framework necessary for creating policy: *"A competitive strategy is a broad formula for*

how a business is going to compete, what its goals should be, and what policies are needed to carry out those goals."

Another useful definition that cannot be attributed to any specific person, but has been common in the academic jargon for a long time is: *"Strategy is the creation of a defensible competitive advantage."*

All these definitions would suggest that the description which encompasses the fullest range of those activities that are necessary components of a successful organization is the one that should be chosen. However, it is not that straightforward because there are some elements of strategy which have universal validity and can be applied to any institution, regardless of its nature. With this in mind Professors Hax and Majluf have proposed a definition of the concept of strategy in which they believe it is useful to separate the concept of strategy from the process of strategy formation. By "concept" they mean its content and substance, a multidimensional concept that embraces all the critical activities of the firm, providing it with a sense of unity, direction and purpose, as well as facilitating the necessary changes induced by its environment. Many dimensions are required for its proper definition and together they emphasize the various components of the concept of strategy, one at a time, and in combination. They propose a more comprehensive definition:

Strategy ....

1) is a coherent, unifying, and integrative pattern of decisions;

2) determines and reveals the organizational purpose in terms of long-term objectives, action programs, and resource allocation priorities;

3) selects the businesses the organization is in or is to be in;

4) attempts to achieve a long-term sustainable advantage in each of its businesses, by responding properly to the opportunities and threats in the firm's environment, and the strengths and weaknesses of the organization;

5) engages all the hierarchical levels of the firm: corporate, business, functional, and;

6) defines the nature of the economic and noneconomic contributions it intends to make to its stakeholders.

From this unifying point of view, strategy becomes a fundamental framework through which an organization can assert its vital continuity while, at the same time, it forcefully facilitates its adaptation to a changing environment.

Strategy Formation

The process of strategy formation is much more elusive and difficult to grasp. The first step is to define the key players in charge of formulating and implementing the strategy -- are they supposed to act as a team, or are they going to be divided into independent groups?. Second, what tasks are those teams going to accomplish and in which sequence?; to what extent will the process of strategy formation be explicitly stated and communicated to the various constituencies both inside and outside the firm?. All these issues are part of the process of strategy formation; and in fact, the process school of research (Bower & Doz, 1979) views strategy as the outcome of three different processes contributing to strategy formation:

- The cognitive processes of individuals where the rational understanding of the external environment and internal capabilities of the firm reside.
- The social and organizational processes that contribute to the internal communication and the development of a consensus of opinion.
- The political processes that address the creation, retention, and transfer of power within the organization.

Within this perspective, the administration of these three processes, requires a broad vision of what needs to be achieved and how to manage a network of organizational forces that lead to the strategy formation process.

Alternatively, there are different ways to characterize this process and this has lead to a large controversy among academicians about how strategy is formed. E.Wrapp (1984) suggested four levels for the definition of corporate strategy and pointed out the various mechanisms that are available to make the process "explicit versus implicit".

Another controversial view is represented by the two schools of thought that espouse "formal-analytical versus power-behavioral approaches" (Ansoff, 1984; Hax & Majluf, 1984). Other ways to establish the strategy formation process arise from the definition of "deliberate versus emergent" (Mintzberg & Waters, 1985) ,and strategy as a "pattern of past actions versus forward-looking plan" (Mintzberg, 1976).

The approach followed in this thesis is based on the idea that strategy is formed by the integration of all these ideas to create a broad typology which delineates a strategy formation process that is responsive to the firm's needs. These are:

Explicit versus implicit strategy:

1. The openness and breadth to communicate strategy, both internally in the organization and to all relevant external constituencies;
2. The degree to which different organizational levels participate;
3. the amount of consensus built around intended courses of action, especially the depth of CEO involvement in this effort.

Formal-analytical process versus power-behavioral approach:

4. The extent to which formal processes are used to specify corporate, business, and functional strategies;
5. The incentives provided for key players to negotiate a strategy for the firm.

Pattern of past actions versus forward-looking plan:

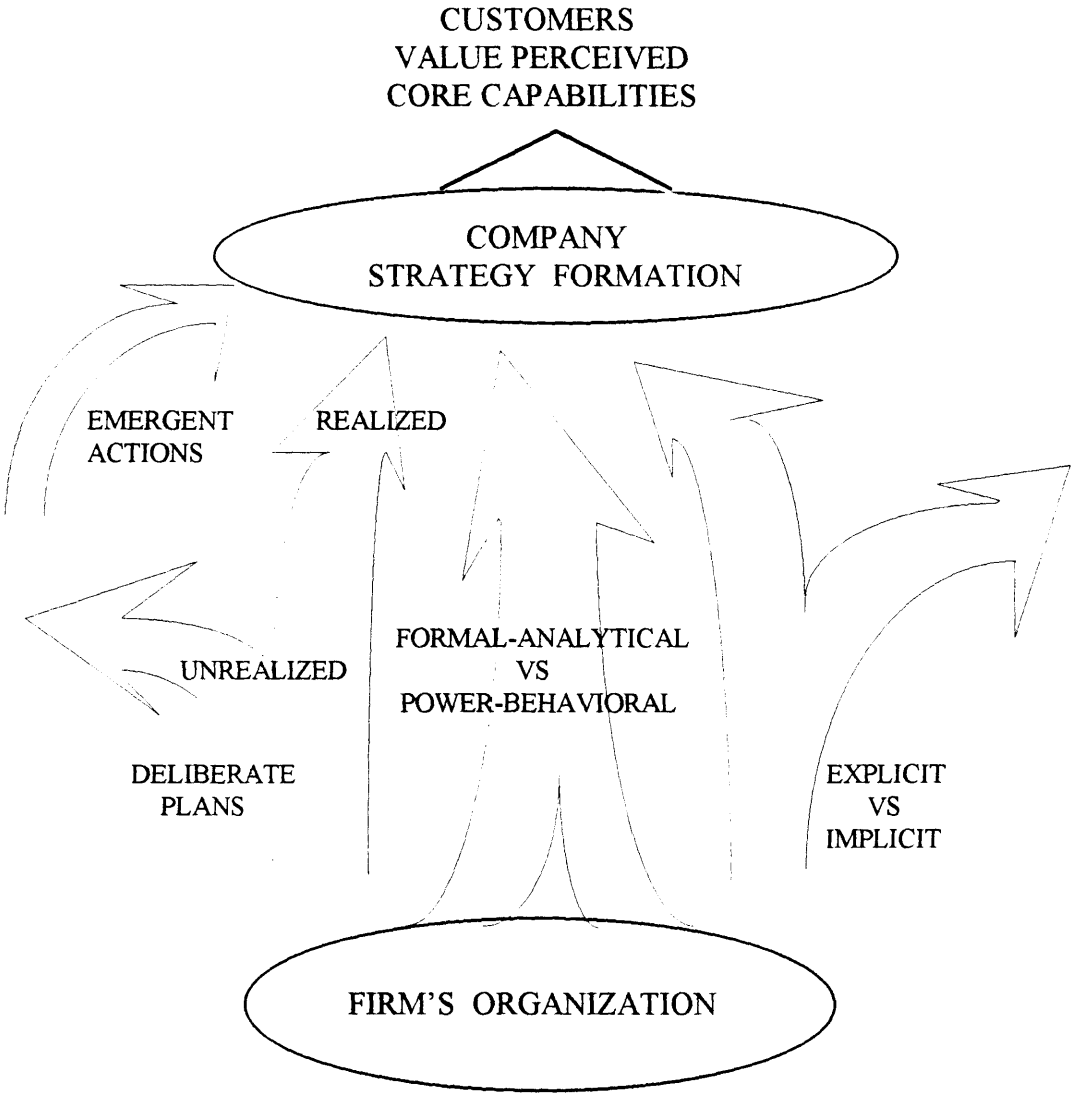
6. The linkage of strategy to the pattern of actions in the past; and
7. The use of strategy as a force for change and as a vehicle for new courses of action.

Deliberate versus emergent strategy:

8. The degree to which strategy is either purely deliberate or purely emergent; (Hax & Majluf, 1991).

Based on this integrated idea, in this thesis I consider the strategy formation process as the one shown in Figure 1.1 in schematic form where the company first carries out a formal-analytical process in which top managers reflect on the company's hypothesis regarding the external environment and its internal capabilities; then some

FIGURE 1.1. Strategy Formation Process



actions plans and programs are establish to achieve company objectives for managing future changes in the organization. But in the real world, forecasts are frequently wrong and certainty is hard to establish. Therefore some initial plans should be dropped and unplanned activities should be on hand to respond to unexpected events. This is when emergent strategy arises to tackle the unexpected situations, identifying patterns or consistencies observed in past behavior, despite, or in the absence of intention (Mintzberg & Waters, 1985).

In this scenario I believe there should be a balance between deliberate and emergent strategies, on how explicit strategy should be communicated both internally within the organization and externally, and the formal discussion of programs and planning to allow a proper definition of company strategy that guides its actions in a coherent way based on the vision of the firm and the mission of each of its businesses. This implies a properly defined framework, and the planning process should allow timely, proper actions and reactions to changes in the competitive environment, particularly in areas such as technology.

The final step is to generate a strategic plan for the technology function that responds to the actual and future positions of the company. Additionally, it should promote the company's core competencies or capabilities to enable it to respond to unforeseen events. The way in which the methodology is implemented helps to create a common view of the present and desired strategic positioning of the company with regard to technology.

1.2 FRAMEWORK, METHODOLOGY, AND THE CORE CONCEPTS

This thesis makes use of the methodology for strategy developed by Prof. A.C.Hax and N.S.Majluf (1991) which assures a proper linkage between corporate, business, and technology strategies, following the framework established by Hax and No (1993) to guide the strategic decision-making process related to the technology function of the firm. The methodology uses the three hierarchical levels, namely, corporate,

business, and functional shown in Figure 1.2. More precisely, the thesis refers to steps 5, 8, and 11 of that process. The basic elements of the framework are shown in Figures 1.3 and 1.4. Both cases imply interactions between the different levels that have to be considered mainly in the mission of the business for corporate strategy and in the definition of specific action programs for functional strategies.

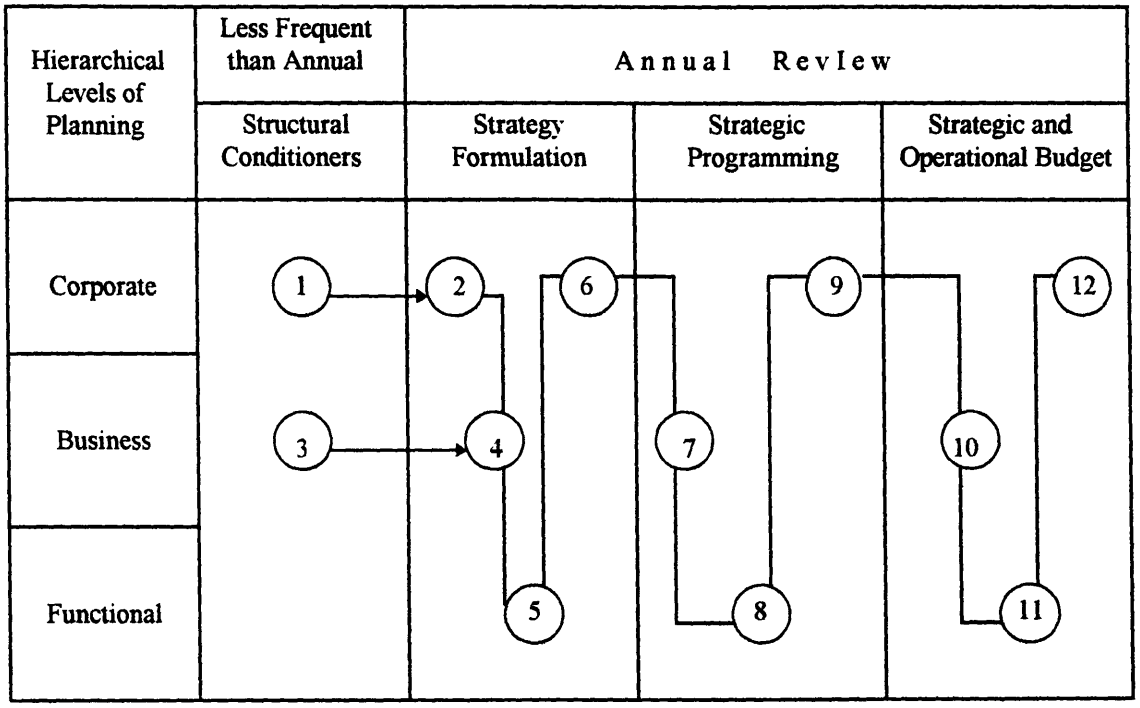
In the business strategy (see Figure 1.3) the initial step is defining a mission of the business that encompasses the proposed changes in products, markets, and geographical scope, as well as to develop actual and future unique ways to compete through core competencies that assure a sustainable competitive advantage. At this level it is important to point out that the business strategy consists in the development and articulation of the elements depicted in the above figure , which are: the mission of the business, the environmental scan and the internal scrutiny, the last two being the must important analytical tasks.

The environmental scan at the business level begins with the assessment of the industry structure and its predicted changes through a determination of the market opportunities and threats. Two alternatives methods are used to carry out this analytical task. The first is Porter's Five Forces model (1980), in which he presented five forces which typically shape the industry structure: intensity of rivalry among competitors, threat of new entrants, threat of substitutes, bargaining power of buyers, and bargaining power of suppliers. The other methodology is the External Factors Analysis to estimate degrees of attractiveness of non-controllable critical elements in order to construct a systematic profile of the industry, analyzing its current state and future projections so as to extract the key factors which impact business attractiveness for the business unit.

The internal scrutiny at the business level looks at the internal capabilities, helping to recognize the actual strengths and weaknesses of the business as well as to decide on reasonable changes in strategic position. This task is comprised of the following steps:

- Identification of key competitors;

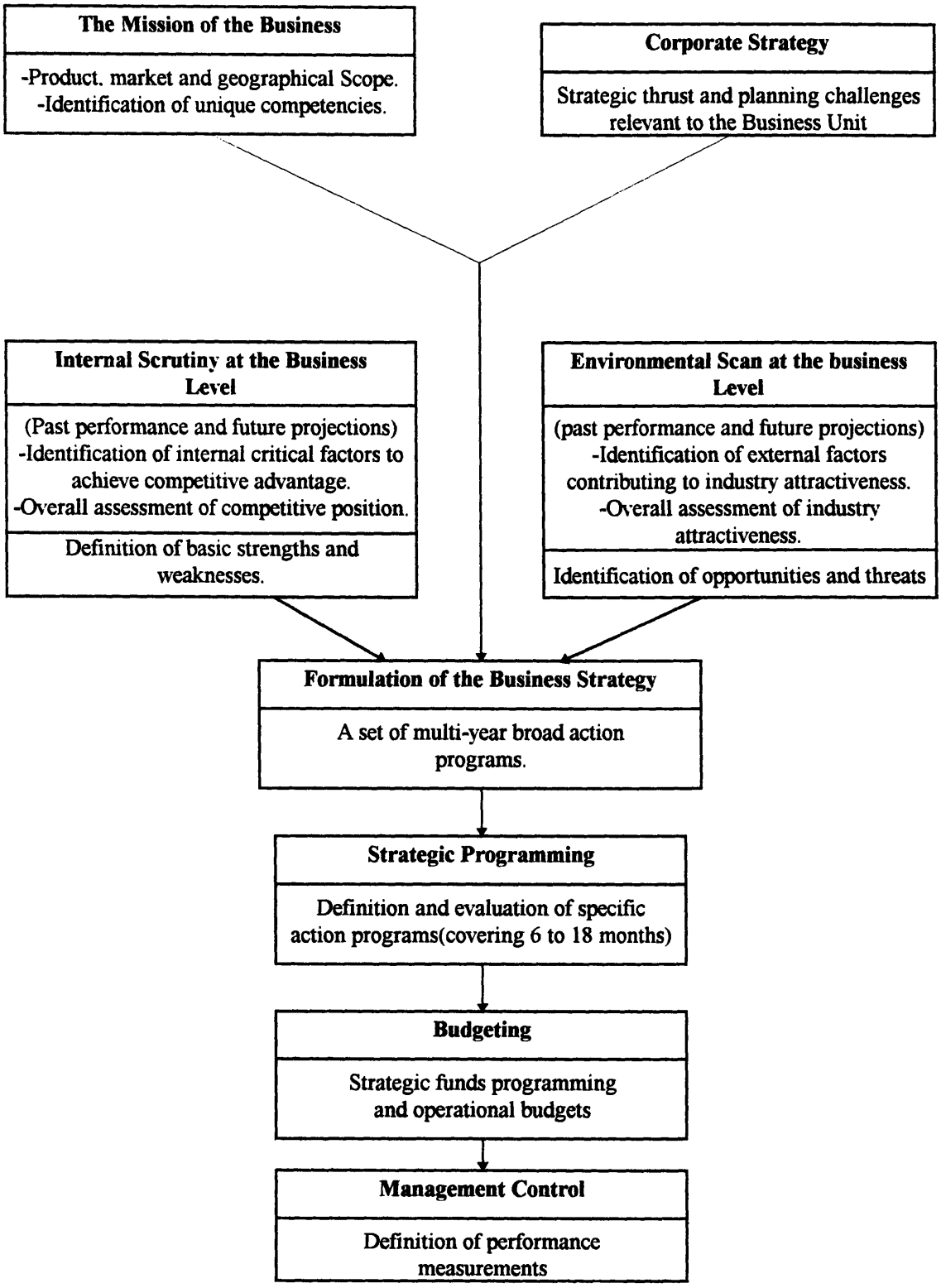
FIGURE 1.2. A Formal Strategic Planning Process



1. Vision of the firm: mission of the firm, business segmentation, horizontal and vertical integration, corporate philosophy, and identification of SBUs and their interaction.
2. Strategic posture and planning guidelines: corporate strategic thrusts, planning challenges, and corporate performance objectives.
3. The mission of the business: business scope, ways to compete, and identification of product-market segments.
4. Formulation of business strategy and broad action programs.
5. Formulation of functional strategy: participation of business planning, concurrence or non-concurrence to business strategy proposals, and broad action programs.
6. Consolidation of business and functional strategies, portfolio management, and assignment of resource allocation priorities.
7. Definition and evaluation of specific action programs at the business level.
8. Definition and evaluation of specific action programs at the functional level.
9. Resource allocation and definition of performance measurements for management control.
10. Budgeting at the business level.
11. Budgeting at the functional level.
12. Budgeting consolidations, and approval of strategic and operational funds.

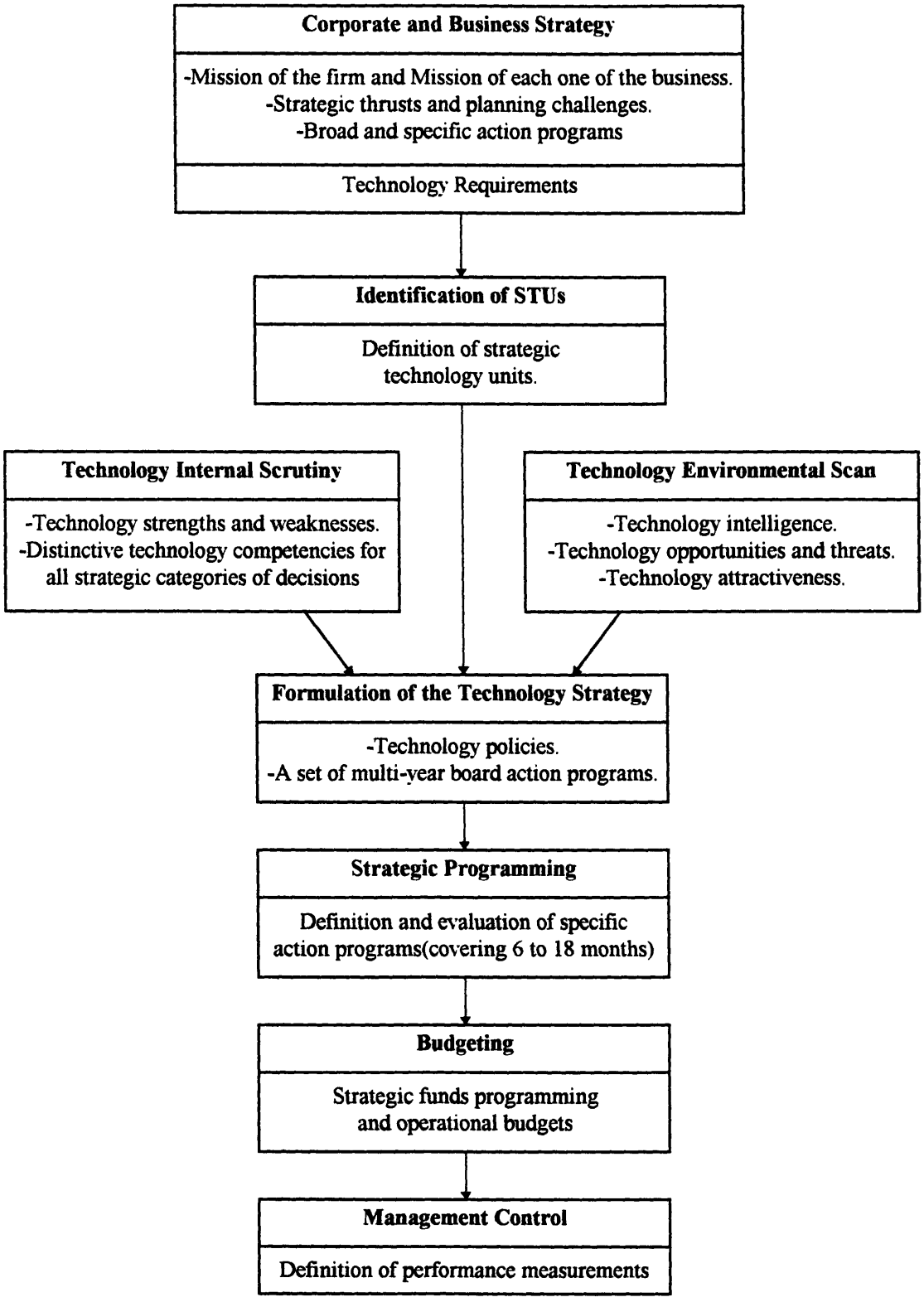
Source: A.C.Hax and N.S.Majluf, (1984).

FIGURE 1.3. Fundamental Elements in the Definition of a Business Strategy



Source: Hax and Majluf, 1991

FIGURE 1.4. A Framework for the Development of Technology Strategy



Source: Hax and No, 1991

- Determination of critical controllable success elements (know-how, skills, etc.) in which the organization has to excel in order to secure competitive advantage;
- Estimating the degree of the business's strengths and weaknesses compared to those of the key competitors by developing profiles; and
- A summary table showing relative strengths and weaknesses.

After analyzing the challenges implied in the three fundamental elements of the Strategic Business Units (SBU) which are: mission of the business, the environmental scan and the internal scrutiny, a multi-year broad and specific action programs should be formulated in order to respond to the three elements. The methodology for technology strategy (functional strategy) consists in the deployment and articulation of the elements depicted in Figure 1.4. In this case, the centers of attention are the identification of Strategic Technical Units (STU), the environmental scan and the internal scrutiny as tasks requiring action at the functional level.

1.3 TECHNOLOGY STRATEGY DEVELOPMENT

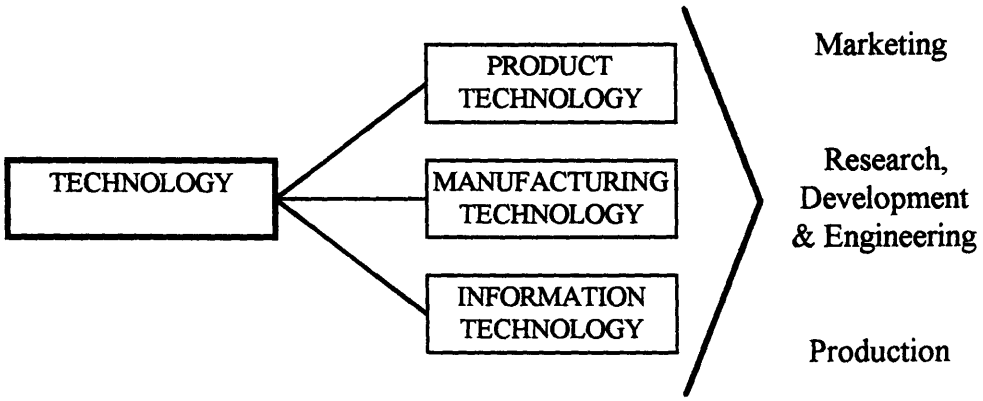
While in the case of business strategy the level of analysis is the SBU, in this case the first requirement is to identify the strategic technology units (STUs) by analyzing the main technologies associated with the business and the core technologies used across the whole organization. In general these will not correspond with the formal structural organization of the company, because technology is a function that in many cases, cuts across different business units, and all these requirements should be taken into consideration. In this case the centers of attention for the environmental scan and the internal scrutiny are the STUs (see Figure 1.4).

The environmental scan is carried out at the STU level, and its purpose is to generate all the relevant information concerning the current and future state of the technology, as well as the opportunities that specific technologies offer for achieving the objectives of the different businesses by having the potential to satisfy the technological

needs. The environmental scan measures technological attractiveness due to intrinsic characteristics; to carry out this step, each technology is measured against a set of external factors to assess the STU's attractiveness for the company and to identify the technology opportunities and threats.

The internal scrutiny at the STU level assesses the technological strengths and weaknesses of the company vis a vis their use of each technology. Two analyses are carried out at this point: first, measuring the company performance to take advantage of specific technologies available for fulfilling the company strategy. The analysis must focus on the overall view of the technology components and the market opportunities as core elements in the business:

FIGURE 1.5. Technology as a system



Source: Adapted from Burgelman and Maidique, 1988

Technology includes a diverse range of related activities that need to be considered holistically. It is important that the fragmented view fostered by organizational structure, educational focus, and career patterns be replaced by an integrated view across the business -- from basic research to product service, and embracing product technology, process or manufacturing technology, and information technology. In the context of a business, this view is very important to fulfilling the real

scope of the internal scrutiny, First we measure company performance in taking advantage of specific technologies that fulfill company strategy; and each STU's strengths and weakness should be measured against how the company succeeds compared with its competitors, in taking coherent advantage of each technology.

The second element of the internal scrutiny looks at how the firm is organized and how the management responds to technology requirements, and identifies the skills or disciplines that are applied to a particular product or process in order to gain technological advantage. One useful way is to analyze the strengths and weaknesses of the firm's existing policies in each of the critical categories of decision making. In the Hax-Majluf (1991) methodology, they propose a list of seven key categories of decisions linked with technology to be considered: Technology Intelligence; Technology Selection; Timing of New Technology Introduction; Modes of Technology Acquisition; Horizontal Strategy of Technology; Project Selection, Evaluation, Resource Allocation, and Control; and Technology Organization and Managerial Infrastructure. All these concepts are further developed and applied in Chapter 4.

The outcome of these considerations (mission of the firm, definition of STUs, technology environmental scan, etc.) is to capture change, either change that is forecasted among those factors the company has no control over, or desired changes in the strategic positioning that the company wants to achieve in a defined period of time. The real value of the analysis is highly dependent upon the quality of the information put in and the caliber of the minds applied to it; for that reason it is very important to have a well-defined framework, and a clear and disciplined methodology which defines a detailed specific action programs at each level and its implementation.

The final result is to provide a more secure foundation for individual programs in the technology strategy process that can guide the firm in developing, acquiring, and applying technology for competitive advantage. Even more important is to understand the need for corrective actions to minimize the typical problems that emerge in the technology development process:

a).-The Moving Target. Too often the basic product or process concept misses a shifting technology or market, resulting in a mismatch.

b).-Mismatches Between Functions. While the moving target problem usually reflects a mismatch between an organization and its external environment, mismatches also often occur within an organization.

c).-Lack of Product Distinctiveness. Often new product development ends in disappointment because the new product is not as unique or defensible as the organization had anticipated.

d).-Unexpected Technical Problems. Delays and cost overruns often can be traced to overestimates of the company's technical capabilities or simply to its lack of depth and resources.

e).-Problem Solving Delays. Every new product development activity involves uncertainty, with regard both to specific problems and conflicts that will inevitably arise, and the resources required to resolve them.

f).-Unresolved Policies Issues. A number of very specific choices and decisions must be made during any product or process development project. If major policies have not been articulated clearly and shared, the choices often force a decision on a policy issue for the entire organization and in this moment inevitably involves senior levels of management and engenders delay and further complications, (Wheelwright and Clark, 1992).

Under such circumstances tremendous amounts of management, technical, and functional expertise are required and managers in general need a much more comprehensive approach to overcome the situations described above and to develop a technology strategy. The formal strategic planning process proposed by Hax & Majluf works well for achieving long-term sustainable advantage over other competitors in the business, generating specific action programs and technology strategy linked with the corporate and business strategies.

1.4 APPLICATIONS AND RESULTS

Here I refer to two relevant recent thesis documents which illustrate specific applications, and the results or conclusions reached by using the framework and methodology established by Hax and Majluf.

From the thesis of M. No (1991):

-Overall the methodology has worked quite well, The following being some comments highlighting some of its most important strengths and weaknesses as viewed from the implementation experience gathered in the Masscalc case:

-The framework used in this thesis has the power to drive the process so as to cover any subject that is relevant for the strategic planning. But, at the same time, it is flexible enough to allow the use as needed of different parameters and tools, the evaluation of the strategic position of a company at the corporation, business and functional levels. Thus, it allows to shape the particulars of the implementation to the unique circumstances of each company.

-The proposed methodology guides the formal strategic formation process to the definition of a set of action programs, budgets and performance measurements that are coherent with company's objectives and with business units strategic standing.

-By focusing on the technological requirements imposed by all the SBUs and by corporate activities together, the methodology ensures that the company will allocate resources in such way that will enhance horizontal technology strategy and will create synergy effect at the core technological values of the company.

-The way the methodology is implemented helps to discuss the mater of technology strategy among technical and nontechnical executives. By doing so, it creates a common understanding of

technology opportunities and threats, and of company's strengths and weaknesses among people that have so different modes as the VP of marketing and the VP of engineering.

-A final awareness should be made: the methodology takes time to be applied. It requires time from the management of the company and it requires dedication from the facilitator. Nevertheless, both investments pay back.

From the thesis of J. Allona (1993):

-The thesis uses the methodology for business strategy developed by Hax(1991) which assures the proper linkage among corporate, business, and functional strategies. This basic framework, used in the business strategy has the ability to guide the process so that all elements are covered that are important for strategic planning. The software utilized in this thesis permits the organization of vast amounts of data collected from the firm.

-The outcome of this analysis has been a set of actions programs that cover: the technology requirements of the business strategy; the challenges from changes in the technology function; the technology opportunities and threads; and the technology strengths and weaknesses. These action programs ensure the competitive technology advantages with the VREE business strategy.

I believe all the literature presented in this chapter can be applied successfully to the analysis and implementation of a methodology for a flat glass company which will help determine a set of issues to be considered in the strategy formation process, and establish a set of coherent action plans for the technology function.

1.5 STATEMENT OF WORK METHODOLOGY

By applying the methodology developed by Hax and Majluf (1991), the intent of this thesis is to develop a technology strategy for Vitro Flat Glass Division in the glass manufacturing business. The technology strategy should respond to the actual and future positions of the business unit, and it should promote the company's core competencies, thereby enabling it to respond to unforeseen events. Also it should provide insights that will be the foundation for developing a full technological strategy for all the related businesses of the division according to the corporate objectives. Based on this analysis, the thesis will offer clear guidance for technology strategy formulation.

The first step in the methodology consists of the deployment and articulation of the elements depicted in Figure 1.3 for the business strategy. The three fundamental elements in the definition of the business strategy are: the mission of the business and the two analytical tasks -- the environmental scan and the internal scrutiny. Throughout the process, there is frequent need to go back and forth and work again on previous steps until the whole material is coherent. Then the methodology for technology strategy (functional strategy) is formulated as depicted in Figure 1.4, consisting of the deployment and articulation of three fundamental elements: the identification of Strategic Technology Units, and the two analytical tasks -- the environmental scan and the internal scrutiny. The final goal is to assess how well each STU will support the firm strategy. The information for this work has been collected through a literature search and direct contact with the company itself for gathering qualitative data.

At present, the methodology has runs on a software called "Business Strategic Planner" (BSP) version 2.0, that permits the organization of vast amounts of data collected from the firm during the process, and permits the creation of a balanced theory and practice in a more pragmatic approach to developing business strategy. The software was developed by Electronic Data System Corporation (EDS) using MacApp® software, and is licensed only for use in combination with the BSP tool. Unfortunately I did not use the software due to an equipment limitations.

CHAPTER TWO

OVERALL ASSESSMENT OF TECHNOLOGY AND INNOVATION TRENDS IN THE INDUSTRY

Flat glass manufacturing is a well-defined industry with a relatively stable technological environment, and where each player tend to have similar technologies. Innovations for the glass melting and glass forming process are mostly incremental, particularly after the technical breakthrough of the float glass ribbon forming process, which research and development began in the early 1950s and finally in 1959 the first successful production float line was set up in England by Pilkington Brothers PLC. On the other hand consequently there are some industries where the pace of change is more dynamic and the technology more volatile; in these industries major innovations occur frequently and technologies compete in the marketplace at any given time. For this reason, prior to stating the mission of the business, it is useful to do a general analysis of the technology and innovation trends in the industry.

This chapter makes a broad assessment of the technology used in the flat glass industry, introduces some of the models that are useful for performing this analysis, serves as an introduction for the reader to the technology used by Vitro Flat Glass Division in the glass manufacturing business, and finally addresses some key technological points.

2.1 THE DYNAMICS OF THE INNOVATION PROCESS

Much research has focused on how innovations come about, when they became successful in the marketplace and why, what were the sources of innovation, etc. Over the years scholars have observed patterns of successful innovation, but simply identifying patterns does not suggest that successful innovation is fully predictable. In his recent book Utterback (1994) developed a model that explain the dynamic relationship between

product innovation, the marketplace, and the firms that emerge and compete on the basis of particular innovations, and suggests that such a relationship follows a curve similar to that described in Figure 2.1(a). This model established the relationship between product and process change over time and has its origins in work begun in 1974 by Utterback and Abernathy (1975, 1978). The analysis derived from studies of assembled products, such as computers, televisions, automobiles, food processors, and so forth. However (see Figure 2.1(a)), the interrelationship between product and process innovation shown in the model also applies to nonassembled products such as glass, synthetic fibers, petrochemicals, etc. (see Figure 2.1(b)).

In both Figures, it can be seen that product development enjoys an early wave of innovation and during the Fluid Phase the outcomes are highly uncertain, the rate of product change is expected to be rapid, and the new technology is often crude, expensive, and unreliable. The number of companies adopting the innovation increases, most of them start-up firms experimenting with new ideas in the marketplace, and in fact, the market tends to grow around and because of these innovations.

Process innovation generally is behind the product innovation in this early stage, and there are frequent, often major changes in product design and specifications that impede the development of the linked process innovation. Then after a period of many design alternatives, one of the proposed designs becomes the dominant design, thereby setting the standards.

From that point on, the number of companies in the marketplace gradually reduces through what is call the Transitional Phase and eventually the total number of firms stabilizes. In this phase competitive emphasis is on producing products for specific users as their needs become more clearly understood, and product and process innovation start become more tightly linked. After a dominant design or standard is determined, products are likely to become more commodity-like and undifferentiated in terms of function and features, and market share stabilizes. Also the competitive emphasis shifts in favor of those firms with greater skill in process innovation and process integration and with more highly developed technical and engineering skills.

Figure 2.1(a). Patterns of Innovation for Assembled Products

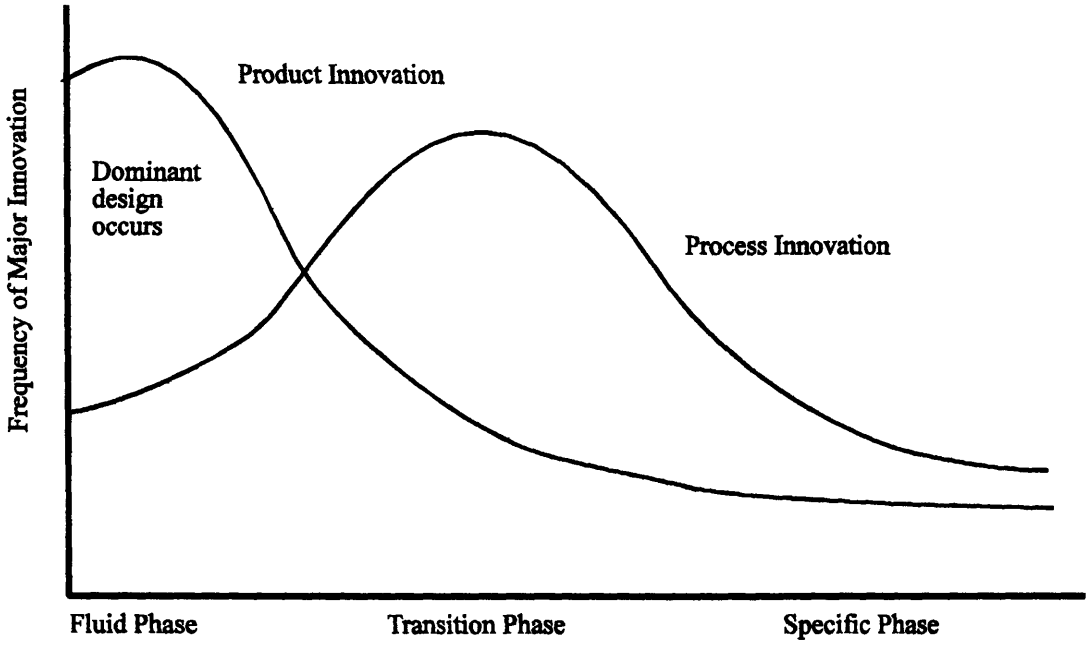
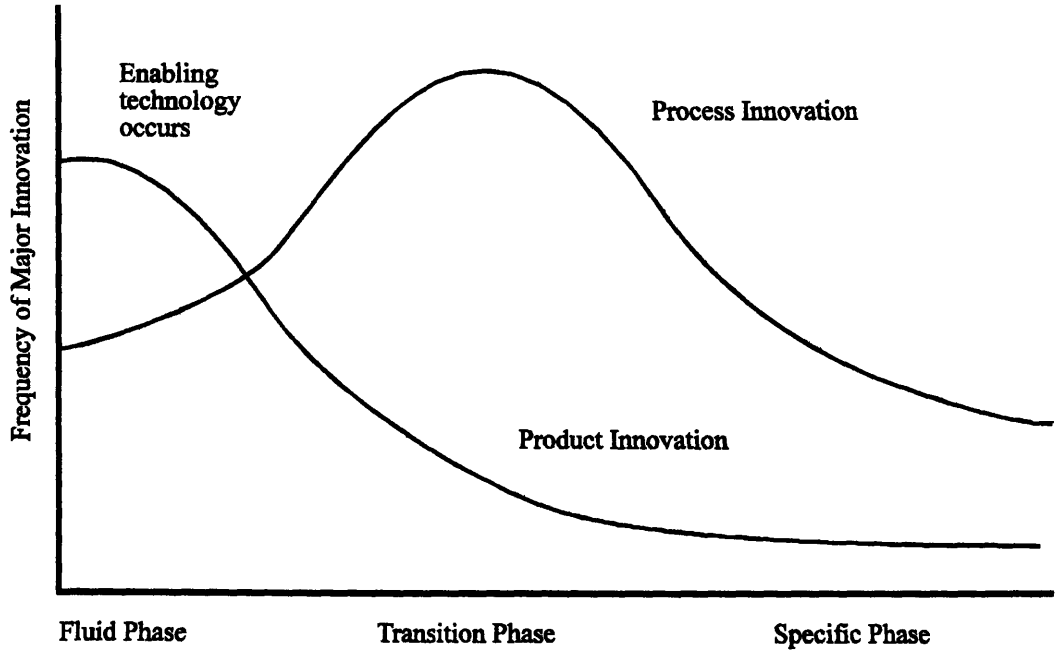


Figure 2.1(b). Patterns of Innovation for Nonassembled Products



Source: Utterback, (1994), p. 130

emphasis shifts in favor of those firms with greater skill in process innovation and process integration and with more highly developed technical and engineering skills.

After that, the Specific Phase begins, producing a very specific product at a high level of efficiency, and here the ratio of quality to cost becomes the basis of competition. The linkage between product and process is now extremely close, and any small change in either is likely to be difficult and expensive. At this point, the firm that produces in this phase has entered a final state from which only a radical innovation in product or process can liberate it.

As mentioned earlier, this model can be applied to nonassembled products, but in a slightly altered form. The question to bear in mind is: Do the processes that manufacture these products pass through fluid, transitional, and specific phases? It would be useful if we could classify products and technologies into sensible groups, between which patterns and details could be observed. Before addressing these issues, however, it would be useful to consider some facts in the evolution of the flat glass industry that illustrate the important issues that bear on the model and on the understanding of process innovation.

History and Evolution of flat glass

Glass, is one of the most ancient building materials. The first known use of glass in windows was probably in Pompeii before the birth of Christ, and was made by shaping the still molten material in a process called casting. It is probable that the ancient Syrians started manufacturing glass around 3000 B.C., and from them the art spread to the Egyptians, Phoenicians, and others. The first flat glass was made by the crown process an entirely by-hand operation in the 7th century. In this process a bubble of molten glass was blown by use of an iron rod and spun rapidly until centrifugal force shaped the open bubble into a flat disk. Rectangular pieces are cut from this and the remaining central piece with the original clump called a "bull's eye" was used for lesser-quality work.

In the 13th and 14th centuries **crown glass** was replaced with sheets of flat glass produced by the handblown cylinder method. By the turn of this century compressed air

did away with the glass blower, and this method became more efficient and less costly in 1903 when the American Window Glass Co developed a cylinder-blowing machine which then allowed for the production of much larger lites or glass panes.

Other methods of producing **sheet glass** eventually replaced the cylinder method, each improving efficiency and product uniformity and reducing cost. These methods were continuous vertical processes where a continuous sheet glass is pulled out of the furnace over rollers, then transferred to the annealing and cutting steps.

Another important method that helps understand the innovation process in nonassembled products is **plate glass**, which has different product characteristics than crown and sheet glass, i.e., thicker, stronger and higher surface quality. It became popular in the 1930 after technology developments lowered its cost. Plate glass had been invented much earlier by French artisans, in 1688. In the French process the raw materials were shoveled into clay pots, which were heated in furnaces and ladled into a box mounted on four-wheeled platform, the platform was then rolled across a casting table and the molten glass flowed through a hole in the bottom of the box. The glass was then flattened by a large metal roller into a plate, and this moved into an oven and allowed to cool (annealing), hardening as it did so. The plate was then ground and polished, and the finished product was a thick plate with perfectly flat surfaces. The entire process took 16 days, since each step of the production process was discontinuous and was performed separately and the glass being moved from one step to another with some delays and nonproductive stages.

The introduction of the first gas-fired Siemens furnace, and thereafter even more important innovations with the continuous melting furnace, steam power, electricity and lehr in the early 1900s helped mechanize plate glass production, so that the entire process took just three days in 1923. Later came the introduction of the twin grinder in 1935, which removed the roller marks from the glass by grinding and polishing both sides of a continuous glass ribbon simultaneously, and very high-quality flat glass was now possible. This brought worldwide technological change to large-scale plate

manufacturing. Now it is just the rolling, grinding and polishing operations that distinguish plate glass from sheet glass.

The latest technology innovation for production of flat glass is the **float glass** process, developed in England in the 1950s by Pilkington Company, after millions of sterling pounds spent, five years of work, and thousands of tons of scrapped glass to develop the float process and build a pilot plant to make it work. In 1959 Pilkington Brothers PLC began making glass using their new process, which made it possible to manufacture glass that is perfectly flat with parallel and smooth surfaces, and the annealed plate needed no grinding or polishing, at a fraction of the cost of plate glass.

In the float glass production process, a continuous ribbon of molten glass is placed on a tin bath chamber; because it is lighter than the tin, it floats, making smooth and parallel surfaces. In the bath, heat is applied from above the glass ribbon and as it progressed through the tin, the temperature is progressively dropped, allowing the glass to cool and solidify while still in contact with the tin. The glass ribbon is then placed in a lehr (a kiln for the annealing process) conveyed on rollers, where it is further cooled and hardened into its final state.

The Pilkington float glass process linked together all the pieces of automation into one continuous process and turned plate glassmaking from being very labor intensive into a highly efficient and automated industry. The float process is much more capital-intensive than other processes, but its efficiencies are much better. The process now almost completely dominates the market for flat glass in thicknesses up to 25 mm, and is incorporated in almost all new flat glass lines, particularly in North America, Europe, and Japan. Only in developing countries where capital is scarce and markets limited do the older technologies still survive.

Improvements continue on the standard float process. However it should be remembered that in science and technology it is, in many ways, an accidental development that leads to a radical innovation or technological discontinuities, but almost always requires technological leadership to become a reality.

PPG Industries, an American company, has developed what it calls a "direct delivery float system", in which a wider stream of melted glass is directed onto the bath of tin, and this reduces the size of the tin bath. In addition, AFG Industries, another US firm, has come up with a 'mini-float' process, which produces flat glass on a small scale, producing 100 tons per day compared to 500-600 tons per day for typical large-scale float production facility.[1]

Innovation in Nonassembled Products

Based on the evolution of several production methods for making flat glass described above, it can be seen that each one involved a combination or elimination of earlier steps, and each resulted in dramatic productivity increases and lower unit costs. Each combination represents, in effect, a change in process architecture; a new process architecture represents a discontinuous productivity advance (Utterback, 1994). The same can be said of instances in which a new process technology is being introduced; for, example in the change from the crown glass to the cylinder glass process, in the first case because of the elimination of an entire process step; in the second case, because the new production technology is inherently more efficient. Since each new process architecture results in lower unit costs, the relationship between time, unit cost, and process architecture looks like a downward staircase, each step representing a change in process architecture.

The changes in process architecture are usually few and far between, and progress toward improved productivity does not stop between their occurrences. In reality, major discontinuous changes are usually followed by a number of small incremental improvements. Different authors have commented on this pattern of change. Schumpeter (1942) noted the periodic occurrence of industrial innovation; Anderson and Tushman (1990) describe how a technological discontinuity is followed by an era of ferment from which a dominant design emerges; Utterback (1994) established: "*in*

[1] For further details, refers to Application of New Technologies in the Glass Industry: Part one, US Glass, Metal & Glazing, 1989, p.68-69.

discussing nonassembled products such as glass, we might easily substitute the term 'enabling technology' for dominant design; here the process of making crown glass, the method of continuous casting, and the float process were all 'enabling technologies' that appeared in a rush and were refined incrementally in ensuing years".

As it was mentioned, product development starts with an early wave of innovation, but its rate slows down and gives way to a growing rate of process innovation. However, because nonassembled products contain a smaller number of different materials, very early on there is a more concentrated focus of technological effort and experimentation in the production process, which goes through similar periods of variation and experimentation, resulting in so-called "enabling technology". This enabling technology incorporates many of the elements needed in a continuous production process and allows the focus of technological effort to shift to process improvement from product innovation and design.

In the product innovation of assembled products the important role of industry outsiders is very widely observed and clearly established. Three main sources of innovation have been defined (von Hippel, 1985):

- the lead users, benefit significantly from using the innovation,
- manufacturers, benefit from manufacturing and selling the innovation, and
- suppliers, benefit by supplying components or materials for the innovation,

and either singly or collectively they often play a key role in product innovation. Similar evidence is seen for nonassembled products, although on a reduced scale, because insiders play a much larger innovative role, particularly in the processes by which they are manufactured. Here heavy emphasis on process innovation for nonassembled products provides manufacturers and the process equipment makers a fertile environment for creating improvements. Glass, like many homogenous products such as chemicals, aluminum, steel, etc., has remained very much the same as a product; what has changed is the process by which it is made. However, the functionality of an assembled product such as the Boeing 747 is tremendously different from that of commercial aircraft of the 1930s. The patterns of innovation for assembled and

nonassembled products are thus different in the sense that the rate of process innovation quickly outstrips the rate of product innovation among nonassembled goods, and process innovation dominates the industry as it passes through the transitional and into the specific phases of its evolution, as shown previously in Figure 2.1(b).

In the analysis between these two models Utterback (1994) writes: *"in the transitional phase, where the differences between assembled and nonassembled products appears greatest, an important reason is that nonassembled products become process driven"*. Figure 2.2 compares important characteristics of the transitional phase for both product classes. This leads to the idea that instead of distinguishing between assembled and nonassembled products, future research might consider a single spectrum graded by number of parts and process operations, with homogeneous products like glass on one extreme, and jet aircraft on the other.

Figure 2.2. Comparison of the Transactional Phase for Assembled and Nonassembled Products

	ASSEMBLED	NONASSEMBLED
Innovation	Emphasis on incremental product improvement and product variation.	Emphasis on process changes required by rising demand.
Source of innovation	Users. manufacturers, suppliers	Manufacturers, equipment makers
Products	Many features unique to individual producers	Increasingly undifferentiated
Production process	Some subprocess automated. creating islands of automation.	Becoming more rigid, more continuous, more capital intensive.
Equipment	Special purpose equipment being introduced	Special purpose equipment.
Plant	General purpose with specialized sections	Single purpose, but small.
Cost of Process	Moderate	High
Competitors	Many, but declining in numbers after emergence of the dominant design.	Many, but declining in numbers after emergence of the enabling process.
Vulnerabilities of ind. leaders	To both improved products and more efficient producers of current products	To more efficient and higher quality producers

Source: Utterback, 1994, p.140

The implications of this analysis for the process of innovation and the enabling technology for the flat glass are:

- The dominant process for glass forming remains the standard float glass process, however a technological discontinuity can occur at any time. The most predictable improvements will continue to be with major equipment innovations, with for multistage operations combining into a one step operation. Also, steps that may have been done in separate productive units can be combined within a new process. Every day more pressure would be on to improve efficiency and higher-quality producers.
- More technological discontinuities will appear in processes to improve the properties or added value to the basic glass plate, as has happened with some breakthroughs in pyrolitic deposition and high-vacuum sputtering. Particularly as needs increase the for better energy conservation performance of windows due to more stringent energy conservation policies and environmental regulations.
- It is clear from the model discussed that the changes solidified the existing production process, a sign of a mature industry in the specific phase. Nevertheless, it has been demonstrated many times that no matter how mature a technology such as, glass may be, there is always room for great improvement and radical innovations. An evaluation of the trade-off between technological innovation and high production efficiency, more systems-monitoring skills, flexible manufacturing acts, will be required.
- Significant attention should be paid to trends such as strategic actions by competitors, an oligopolistic opportunity for market share, and a lower number of main players in the global market. A closer technical liaison should be planned with equipment makers and suppliers to search for sources of innovation and to take the lead as breakthrough innovators and as incremental improvers.

2.2 TECHNOLOGICAL COMPETITIVE IMPACT

The concept of technological maturity places a technology along a continuum of technological advance and helps one to understand the possibilities for additional advances in technology. Like living organism, technologies have life cycles, from birth to old age. This well-understood technological cycle[2], should be connected with R&D activities and strategy since the mission of a company typically changes along with the maturity of the industry in which it competes.

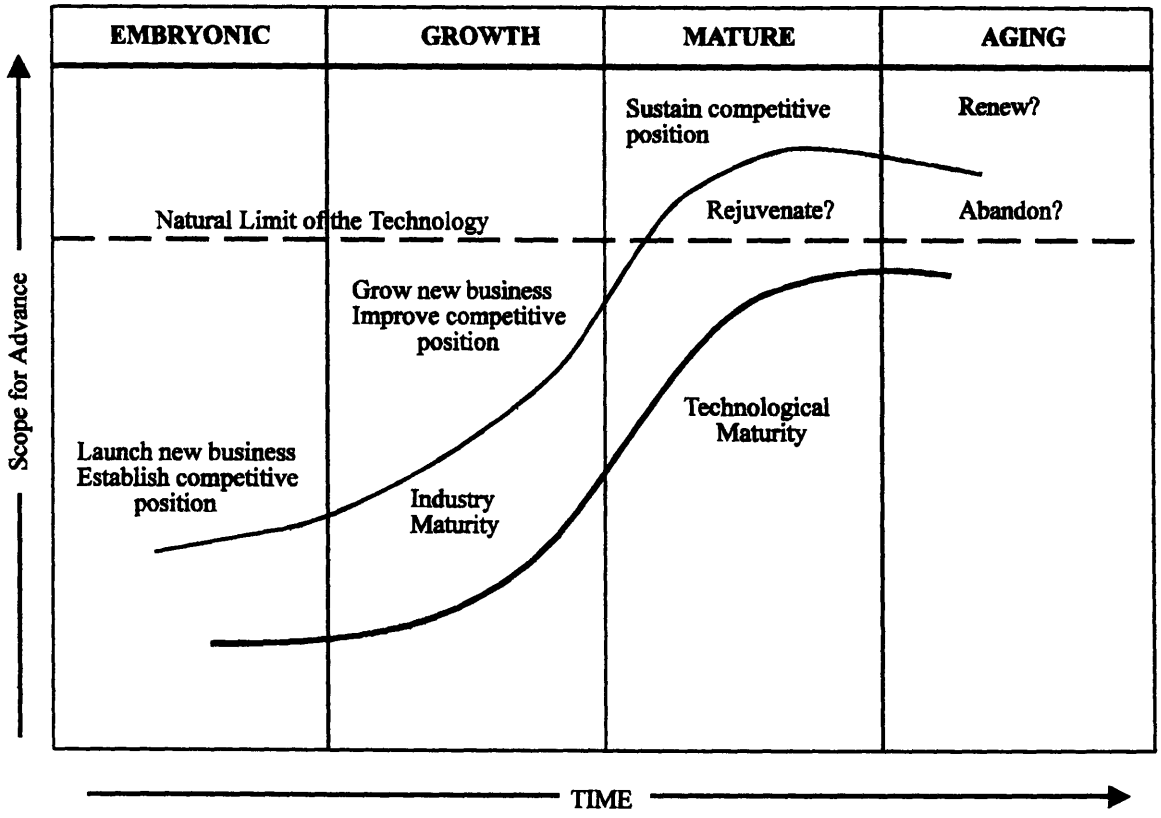
As shown in Figure 2.3, the birth of new technology is called "embryonic". At this stage, the possibility of practical applications exists, but so little of a practical nature is known that the route of future industrial developments is highly uncertain. Instead, the main activity of research is to build and expand knowledge and deal with the substantial scientific tumult and contradiction that may appear. The business mission of industrial R&D at this point is to help launch new business opportunities and to define the company's position by assessing the emerging technology, by demonstrating the validity of probable product concepts, by establishing the viability of the manufacturing process, and doing what is needed to establish and defend the company's intellectual property.

In the "growth stage", the practical technology is sharpened and leads to more realistic forecasts because much uncertainty has been erased. Much knowledge is accumulated and disseminated and impractical applications are abandoned. Here the mission of R&D is to help grow the business and sustain or improve its competitive position by expanding the products' range and applications, by improving features of existing products, and by adapting them to different market standards or regulations.

When the technology and industry becomes "mature", the pace of advances in understanding and development slows, the basic technologies become well understood, and there will be more incremental improvements and more predictable technological advances. Now the strategic role of R&D usually shifts to one of defending competitive position by extending the product differentiation, by focusing on the manufacturing

[2] Refer to Roussel, Saad, and Erickson, Third Generation R & D, 1991.

Figure 2.3 Technologies can be Characterized by their Maturities and The Mission of R&D and the Industry Cycle



Source: Adapted from Roussel, (1991), p. 19 & 61

process and related processes for cost reduction, and by broadening and deepening technological capabilities. Perhaps it is plausible to rejuvenate the business with new technologies and/or licensing.

Inevitably, the last phase arrive and technology and industry advance to the "aging stage", characterized by substantial completion of scientific and engineering advances. There will still be some advance, but they will represent a small increment and be highly predictable. However, equipment makers will continue to make advances in equipment for better control, improve throughput and automation of operations. The classical role of R&D has been sharp focus on cost reduction and providing the customer with technical support; however, strategically, perhaps a better R&D role is to renew the product or manufacturing technology and drive competitors out of business rather than be driven out.

The important role that technology plays is well known in the current competitive industrial environment in order to achieve sustainable technical capabilities for competitive advantage, as well as the critical role of the business/R&D partnership in ensuring profitability and a balanced portfolio of R&D for companies in competitive environments. At present, R&D must seek to respond to the needs of existing business and to the additional needs of the corporation, while at the same time contributing to the identification and exploitation of technological opportunities in existing and new business.

Roussel, Saad, and Erickson (1991) propose several concepts and describe a philosophy of "planning principles that equip business and R&D executives to play their vital roles in integrating business and R&D strategies and the operational principles that make that process work". Some attractive ideas collected from these authors are important for characterizing the technological life cycle. They are discussed below.

The generalized characteristics of technology maturity are summarized in Figure 2.4, which shows that for strategic planning in R&D, the maturity of the technologies in which the company invests results in highly important consequences and must be incorporated into prudent R&D plans.

Figure 2.4. Characteristics of R & D as a Function of Technological Maturity

Techno-logical maturity	Time to comm-ercialization	Knowledge of competitive R&D	Predictability			Durability of commercial advantage
			Technical	Reward	R&D cost	
Embryonic	7-15 yr.	Poor	Poor	Fair	Poor	High
Growth	2-7 yr.	Fair-Moderate	Fair	High	Moderate	Moderate
Mature	1-4 yr.	High	High	High	High	High
Aging	1-4 yr.	High	Very High	Very High	Very High	Short

Source: adapted Roussel (1991), p. 63

Another R&D planning concept, the competitive impact of technologies seen in Figure 2.5, provides valuable insights into the nature of which R&D should be undertaken and which should not.

Figure 2.5. Competitive Impact of Technologies

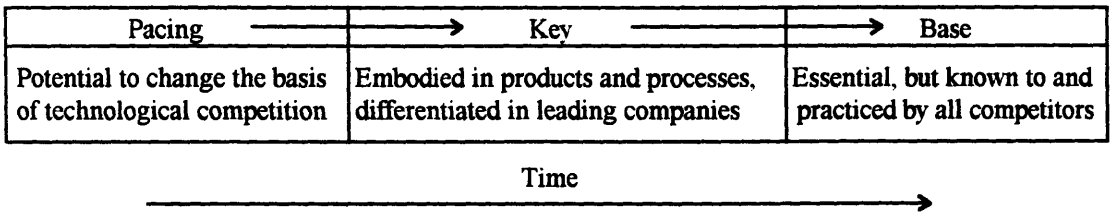
Descriptor	Competitive Impact
Pacing Technology	* Technologies that have the potential to change the entire basis of competition but have not yet been embodied in a product or process. * Theses technologies often develop into key technologies.
Key Technology	* Technologies that are most critical to competitive success because they offer the opportunity for meaningful process or product differentiation. * These technologies yield competitive advantage.
Base Technology	* Technologies that, although necessary and essential to practice well, offer little potential for competitive advantage. * These technologies are typically widespread and shared.

Source: Roussel (1991), p.64

There is a natural progression in the competitive impact of technologies, typically represented by a progression over time from "pacing" to "key" to "base" technologies, as illustrate in Figure 2.6. Technological maturity is intrinsic to a technology, regardless

of the industry in which it is applied. The competitive impact of a technology is extrinsic, and is closely dependent on the industry that applies it.

Figure 2.6. Competitive Impact of Technologies Over Time



Source: Roussel (1991), p. 65

The strategic mission of R&D is to exploit the potential for improving the competitive position of technologies that are important to the business. These are first and foremost key technologies, then pacing technologies, and, always competence in base technologies. The maturities of technologies in the business provide insights into the potential for future technological advances. The two concepts -- technological maturity and technological competitive impact -- and how well they are mastered are clearly basic to effective R&D planning.

There is no doubt that all these concepts, together with an understanding of the implications addressed by the innovation process, establish the background information to identify the key technical issues in coherent way for the process of strategy formation, to guide the strategic planning process and its link with technology strategy in order to achieve a sustainable competitive advantage. This process is further developed in the following two chapters. Also complementing and augmenting these concepts, is the basic framework for the development of technology strategy proposed by Hax and Majluf (1991). Adequately generated and properly used technology may be a major tool to support the competitive strategy of a company.

CHAPTER THREE

BUSINESS STRATEGY

As mentioned earlier the methodology for this work is based on the framework suggested by Hax and Majluf (1991). This chapter illustrates the methodology for business strategy and its link with technology strategy, and shows how it can be applied to Vitro Flat Glass Division. The company chosen to implement the strategy, has several business units, but for this thesis only the glass manufacturing unit has been chosen for analysis. Therefore, the corporate and business strategies collapse into the same unit, and this allows me to show how the methodology is applied without needing to specifically develop the corporate strategy [1].

The concept of a Strategic Business Unit (SBU) allows the development of a strategic planning process. There are three fundamental elements in the definition of the business strategy:

1).- The mission of the business,

2).- the industry attractiveness in which the business belongs (with a planning process referred to as an environmental scan), and

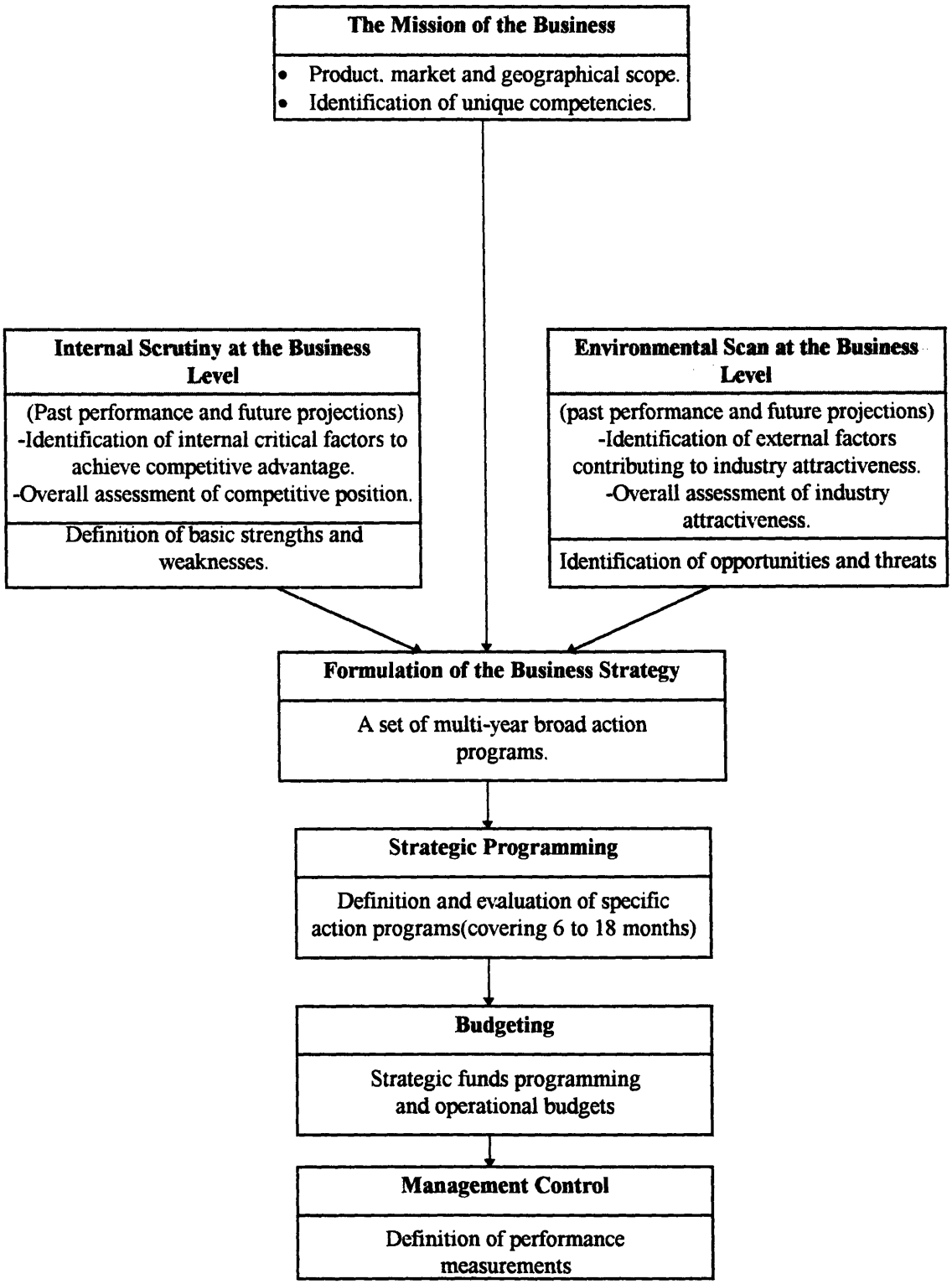
3).- the competitive position of the business (referred to in the planning process as the internal scrutiny).

This elements of the framework are depicted in Figure 3.1, which provides a basis for coordinated action within the organization and consequently the development of broad action programs.

The application of this methodology to Vitro Flat Glass Division is shown with special emphasis on the development of the technology requirements as an outcome of the broad action programs.

[1] The methodology for technology strategy is of general application, and hence, it is applicable to companies with several SBUs. Though the case includes only one SBU, for further details of the framework in treatment companies with several SBUs, refer to Hax and Majluf, 1991, for business segmentation at the corporate level.

FIGURE 3.1. Fundamental Elements in the Definition of a Business Strategy



Source: Hax and Majluf, 1991

3.1 BACKGROUND OF THE COMPANY

Vitro Flat Glass Division, named Vitro Vidrio Plano (VVP) is one of the operating core businesses of Vitro Group. Vitro is the largest private industrial group in Mexico and controls 80% of the Mexican glass container market and 90% of the flat glass market. The Flat Glass Division began operations in 1936 when its former company, Vidrio Plano S.A. de C.V. was founded in Monterrey. The growing needs of the market led to the creation in 1955 in Mexico City of Vidrio Plano de Mexico S.A. de C.V., which in 1968 installed the first float glass line, a revolutionary process that increased enormously both production and glass quality. This was a crucial step in Vitro's development.

At present Vitro Vidrio Plano (VVP) has 7 companies with operations in Mexico, and a subsidiary in the US called VVP America Inc. In 1992 VVP acquired ACI America Inc., which is the US market leader of flat glass products, with over 120 fabricating, distribution, and retail sales units in the western and southern United States. VVP uses different technological processes and equipment to produce clear and tinted float glass, tempered, laminated, bulletproof, reflective, insulated and mirrored glass for architectural, decorative, and automotive uses, and also designs and manufactures glass table tops.

I believe glassmaking, as a continuous process, is facing some challenges in process technology, productivity, and major equipment innovations; on the other hand several added-value products such as the reflective glass, with a new generation of product technology and technological competition. Market positioning and distribution are facing new challenges, with more emphasis on customer-oriented service. Now leadership in cost manufacturing, technology, and marketing intelligence becomes crucial, and new perspectives for managing industrial R&D are needed in our highly competitive environment.

3.2 MISSION OF THE BUSINESS

The vision of the firm, usually stated as a broad declaration of purpose with soft terms, expresses how managers understand the future of the firm and may act as a basic force for the organization. This is the starting point, however, the vision has to be translated to set quantitative targets and establish time horizons for the SBU and this is done through the formation of the mission of the business.

In the methodology, the definition of the mission of the business is centered on detecting the changes to be undertaken in business scope and core competencies, identifying the resulting challenges emerging from those changes, and reaching a consensus on the direction of the business.

Throughout this step, there are two sets of key information that should be contained in the mission statement:

- one is a clear definition of current and future expected business scope that implies the selection of customers and, consequently the competitors, which then defines the competitive domain in which the business operates (products, markets and geographical locations);
- the other is the unique competencies that determine the capabilities of the business, taking into account the various ways to achieve competitive leadership and differentiate the business from others in the same industry.

In formulating a mission statement for VVP, the actual circumstances of the division will be examined; reasonable expectation for the future with regard to the product, market and geographic scopes will be stated; priority assessments set; and segmentation matrices drawn, taking into account the various ways of achieving sustainable advantage. Throughout this process,, attention is paid to the current situation and future projections [2].

[2] The time span included in the expression "future" will depend on the industry. An appropriate time for one industry may not be suitable for another, and should be such that allows it to focus the strategic actions of the company; if it is too brief it could result in shortsighted planning, and if it is too long it could lead to overly speculative planning.

The primary information in the mission of the business is the change that is implied in the description of present and future scopes. During this part of the process, management has to focus on capturing the change, and on achieving agreement about which are the most significant challenges that the business has to face, not only for what it includes, but also for what it leaves out. The priority assessment is done on a five-point scale as indicated in Figure 3.2 (for priority assessing the business scope), and Figure 3.3 (for assessing unique competencies); where prioritizing the items makes it clear how much effort and resources will be allocated in the future.

In the case of VVP, as I collected information about the development of the mission of the business, I found the following sentence which reveals the long-term objective of the SBU:

> **The glass manufacture business should achieve a global standard of excellence and while being the lowest cost producer in the industry, offer superior quality and service, continuing innovation of the current product line, with competitive technology in all aspects of the value chain of the business.**

Figures 3.4 to 3.6 show the product-market-geographical scopes with current and future conditions and their corresponding priority assessment, where priorities signify allocation of resources into the future. It is important to mention that glass manufacturing development should be seen in the context of the float process which will, over the near future at least be the key process for manufacturing the raw materials. The trend over recent years has been toward more added value and higher performance through processed basic glass products such as tempered, laminated, insulated and coated glasses. The market scope shows the existing and new market in which VVP is and will be involved, represents how we segment the market, and represents the consumers and customers using VVP products.

FIGURE 3.2. Priority Assessment Scale for Business Scope

Priority	THE PRODUCT, MARKET, GEOGRAPHICAL LOCATION	
	Current Scope	Future Scope
- -	...is being divested or exited from.	...is very tentatively considered for business activity.
-	...will be assigned a low level of importance.	..is tentatively considered for business activity.
E	...will continue to receive the current level of resources.	...will receive the necessary level of resources.
+	...is assigned a high level of importance and additional resources to achieve a better competitive position.	...will be assigned a high level of importance and the necessary resources to achieve a strong competitive position.
++	..is assigned the highest level of importance and the resources needed to achieve as outstanding a competitive position as possible.	..will be assigned to the highest level of importance and the resources needed to achieve as outstanding a competitive position as possible.

FIGURE 3.3. Priority Assessment Scale for Unique Competencies.

Priority	THE UNIQUE COMPETENCIES	
	Existing	New
- -	...no longer will provide competitive advantage.	...could become a source of competitive advantage, but its significance is highly uncertain.
-	...will only provide a minor competitive advantage.	...could become a source of competitive advantage, but its significance is mildly uncertain.
E	...will be a source of significant competitive advantage.	...will be a source of significant competitive advantage.
+	...will be a source of very high competitive advantage.	...will be a source of very high competitive advantage.
++	...will be a source of most critical and highly differentiated competitive advantage.	...will be a source of most critical and highly differentiated competitive advantage

Figure 3.4.- Existing and New Product Scope

Existing Product Scope	--	-	E	+	++
* Clear Float Glass		■			
* Colored Float Glass				■	
* Automotive Float Glass				■	
* Reflective on-line					■
* Architectural			■		
* Top Tables and Forms			■		

New Product Scope	--	-	E	+	++
* Reflective off-line					■
* Architectural (sun-rooms)			■		
* Rolled Plate Glass (new patterns)				■	
* Glass Clean Protector			■		

Figure 3.5.- Existing and New Market Scope

Existing Market Scope	--	-	E	+	++
* Large Dealers			■		
* Small Dealers				■	
* Commercial Buildings			■		
* Residential		■			
* Auto-Glass Processors					■

New Market Scope	--	-	E	+	++
* Medium Retailers				■	
* Maquila [3]					■
* Decoration / Interiors				■	
* Fenestration			■		

Figure 3.6.- Existing and New Geographical Scope

Existing Geographical Scope	--	-	E	+	++
* Domestic			■		
* United States					■

New Geographical Scope	--	-	E	+	++
* South America			■		
* Central America					■

[3] Spanish word, it poses some problems to its translation. Refer to Knight (1992), p. 93.

The selection of unique competencies are abilities that give the business the means to sustain competitive advantage, and this information should be included in the mission of the business. Figure 3.7 describes these core competencies in the usual span time, which is 3 to 5 years.

The following steps summarize the result of the previous analysis, by listing the new business challenges that arise from the changes we expect in the business. Each critical change in product, market and geographical scopes, and unique competencies is addressed in the form of a challenge. These challenges should be specific and explain what will be done to bring about the desired change. The most important challenges found in the assessment are:

Challenges emerging from product scope:

- To expand production capacity to other float units for the reflective on-line process to gain manufacturing flexibility.
- Focus greater effort on the reflective off-line technology and product development,

  considering its versatility to meet the increase trend in energy conservation and aesthetic architectural requirements.
- To increase the penetration of rolled plate glass as a decorative element with the assessment of new, more attractive patterns.
- Focus explicitly on the potential growth requirement for developing a technology which economically reduces or eliminates the need for cleaning glass.

Challenges emerging from market scope:

- Intensify marketing efforts to increase customers via small dealers and medium retailers

  Target the decoration /interiors market with specific marketing efforts. These are not necessarily commodity products.

Figure 3.7 Existing and Unique Competencies

Existing Unique Competencies	--	-	E	+	++
• Technology					
Image of environmentally safe company and ecological awareness				■	
Packing Development and Transport Systems			■		
Technical Skills in the reflective off-line Process					■
• Managerial Infrastructure					
Management Knowledge of the market				■	
Create an image of Customer Oriented Service					■
Evaluation and Reward System			■		
• Manufacturing					
Up-grading Float Furnace Capacity				■	
Improve Productivity Level / Low Cost					■
Increase Process Flexibility in Top Tables Manufacture.				■	
• Marketing					
Strong Customer Relationship and Loyalty				■	
Strong Brand Recognition		■			
Improve Marketing Forecast			■		
• Retail and Distribution					
Strong Distribution Network			■		
Usage of US Subsidiary distribution network				■	

New Unique Competencies	--	-	E	+	++
• Technology					
Develop an Information Technology System					■
Policy for Resources Allocated to R&D				■	
Product Development and Innovation					■
• Managerial Infrastructure					
Mechanism for Integrate Outstanding Teams					■
Transnational management and global market view				■	
Increase Personnel Commitment and Ownership				■	
• Manufacturing					
Evaluation and Up-grading off-line Reflective Products					■
Rapid Development to Market Time (trials)				■	
• Marketing					
Selective Products Outsourcing			■		
Develop Strategic Alliances with Customers				■	
Develop a Marketing Intelligence					■
• Retail and Distribution					
Increase Power of the Distribution Channel				■	

- Target the maquila industry[3] to increase market share.
- Develop a strategy to assess the fenestration market due to increasing industrialization, off-site fabrication, large facade components, new methods of assembly and factory fabrication.

Challenges emerging from geographical scope.

- Develop a strong position in the American market, using the basic products through the US subsidiary.
- Develop alliances for distributing the basic products in Central American countries
- Develop a strong position and loyalty in the distribution channels for the domestic market.

Challenges emerging from unique competencies (Technology scope).

- Develop appropriate technical skills in the off-line reflective process.
- Develop an integrated information technology for an effective management practice.
- Improve the mechanism to integrating outstanding teams to intensify product development and innovation.
- Evaluate and define the policy for resources allocated to R&D.
- Develop a company image of an environmentally safe company that is ecologically aware.
- Develop a market intelligence and tighten the relations with production and R&D.

The mission statement is a synopsis of the overall scope which summarizes the key points with regard to products, markets, geographic locations, and unique competencies; that indicates where the business stands and where efforts will be directed

[3] The word "maquila" although common these days, poses some problems for translation. It seems to have originated in Spain. At present, in practical terms a "maquila operation" is production sharing by two companies, one the contractor, the other a sub-contractor, resulting in a finished product. For an additional reference see: Knight, 1992.

in the future. This statement should be more concise and focused, but not without substance.

Mission Statement of VVP Division

Glass Manufacture Business Unit

VVP Division is devoted to manufacturing flat glass products of superior quality and value to customers based on the traditional principles of integrity, with world-class excellence, and recognized as the best choice. To satisfy the needs of evolving demands, and thoroughly understand the profitability of the current product line, VVP is committed to expanding its present domestic and international markets, while diverse considering market opportunities. Its purpose is achieved through an organization driven by a devoted management team, excellence and a spirit of continuous improvement.

■ **Product Scope:**

NOW: Manufacture a complete range of flat glass products for the construction, transport, household appliance, furniture and decorative industries and improve the distribution channels.

FUTURE: Maintain domestic market leadership in the same segments, and focus on the technology development of reflective glasses in on-line and off-line process to improve yields and introduce new products. In addition, assess the introduction of new patterns in rolled plate glass and new technology development in glass-cleaning media.

■ **Market Scope:**

NOW: Become the best option in the domestic market, and reinforce penetration through direct distribution via small dealers and large retailers, as well as incremental growth in the maquila industry.

FUTURE: Respond effectively to-ever increasing demand in the domestic market, develop a strategy of expanding the decoration market, and cover broader segments in the industrialized fenestration market.

■ **Geographic Scope:**

NOW: Increase position in the American market through selling efforts to the US subsidiary and encourage loyalty among the domestic market distributors.

FUTURE: Expand progressively through distribution alliances into the Central American countries.

■ **Unique Competencies:**

NOW: Maintain leadership in environmental and ecological awareness and improve technical skills and R&D efforts in glass reflective processes. Focus on low- cost manufacture and continue promotion of effective cross-functional teams.

FUTURE: Develop a strategy for an effective information technology system to allow an integrated approach and more direct impact on managerial practices, particularly in the key functional areas: RD&E, marketing, and production. The Division will develop a transnational culture and global market view for a sharper focus on the differences among various countries and market segments.

3.3 ENVIRONMENTAL SCAN

An important step in developing business strategy is to carryout an environmental scan of the industry within which the company operates. It should be implemented in a way that supports a clear understanding of all those factors that have and will have influence over the success of the company and also it helps determine the opportunities and threats VVP will encounter in the flat glass market. The analysis will be applied

using my own knowledge, and the assessments and evaluation are my subjective judgment about the industry, based on general data and public information from the company; consequently I take full responsibility for the analysis herein.

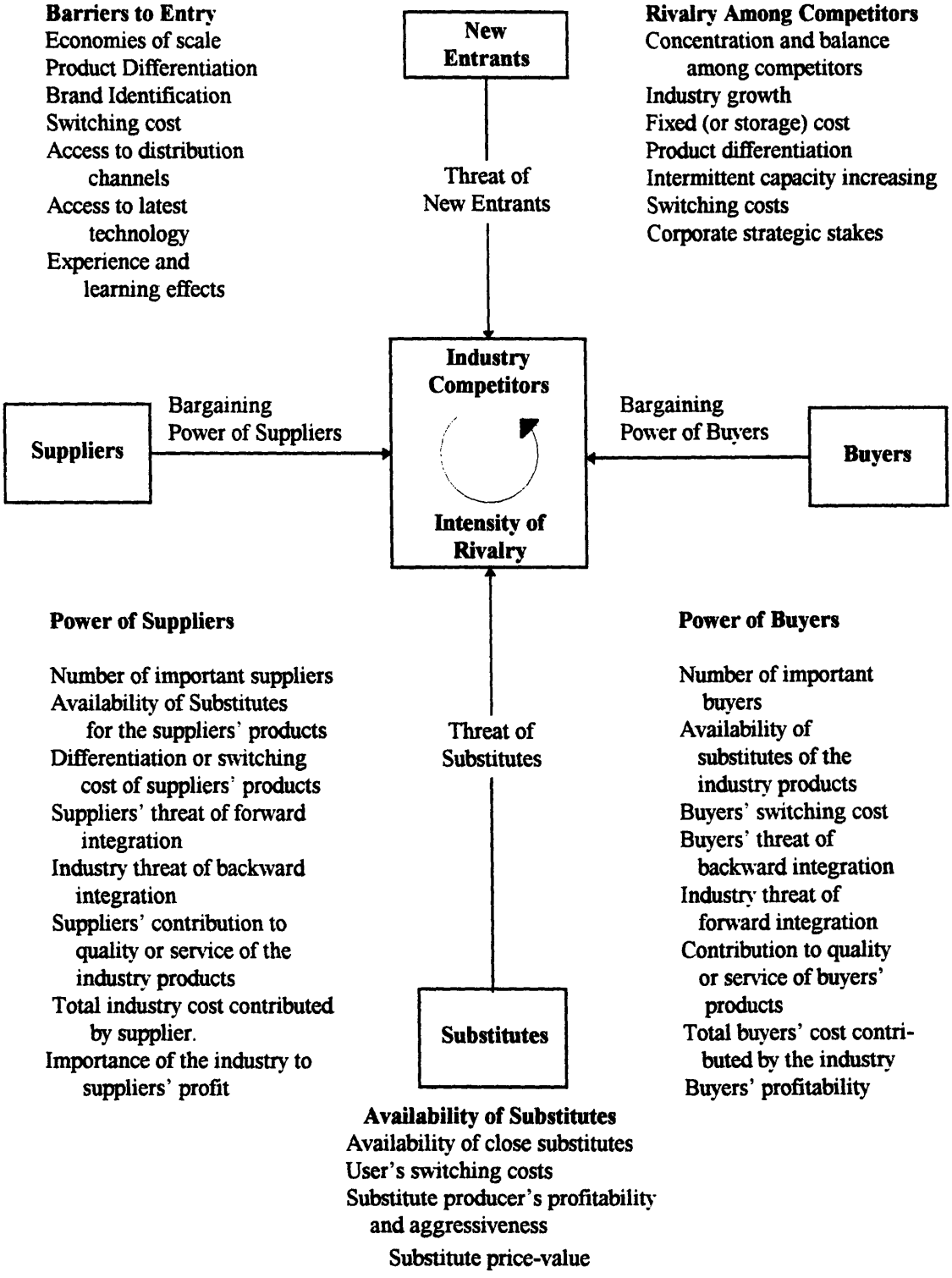
The most influential and widely used framework for evaluating industry attractiveness is the five forces model proposed by Porter (1980). Porter's model suggests that to a large extent the industry differences can be explained by five factors: the current intensity of competition, the presence of substitute products, the power of buyers, the power of suppliers, and potential new entrants, (see Figure 3.8). However, in this case there will be two modifications: (1) the threat of potential new entrants can be expressed through the barriers to entry, and (2) barriers to entry should be complemented by analysis of the barriers to exit and the impact of government actions (Hax and Majluf, 1991) to capture issues of regulation and protectionism that are critical to determining industry attractiveness.

Although this analysis refers to external factors, at the center should be the company itself. The weaker the forces collectively, the greater the opportunity for superior performance, and vice versa. Keeping the focus on VVP, I will present the assessment of each force followed by brief comments, then an external mapping of the market and technological factors in order to understand the challenges facing the VVP division. From this framework, the technology strategy formulation for the company can be established.

Creative entrepreneurial activity is in large measure the ability to see where new lucrative opportunities are likely to arise, as well as where the threats are and how to manage them to minimize or overcome their effect. Also it is important that managers constantly ask themselves some fundamental questions to test out alternative strategies:

- What protects my strategy against encroaching entry and imitation by existing rivals?
- I am unprotected and imitation does occur, what can I do to maintain good performance in the new era?
- What are the core technologies that will sustain a competitive advantage?

Figure 3.8 Porter's Five Forces Model: Elements of Industry Structure



Source: Adapted from Porter (1985)

- How appropriate is the technology used in the float process and in the coating process for reflective glasses?
- How should resources be allocated for technology development?
- What should the company innovate in product/service and production/ distribution systems?

Precisely in order to rationalize this kind of questions, the disciplined methodology proposed by Hax and Majluf thoroughly reviews each of the factors in Porter's five forces model, gives an overall assessment of the attractiveness of the industry, and finally identifies the resulting opportunities and threats posed by the industry.

Threat of New Entrants: Barriers to Entry

This force refers to the offsets in a given industry caused by new entrants who usually bring new capacity, the desire to gain market share, and often substantial fresh resources. It is clear that in practice all possible entrants into an industry do not look the same; while some parameters may look unattractive for many companies, those same parameters can be highly attractive for others. It can be established that:

> *Potential entrants should focus very clearly on important events that are out of their control as a way of understanding the danger areas of the market (Oster, 1994).*

Figure 3.9 shows the assessment of factors for this force and ranks the degree of their effect on the industry..

Figure 3.9. Barriers to Entry

Current oooooo Future ^^^^^^		Highly Unattra.	Mildly Unattra.	Neutral	Mildly Attract	Highly Attract.	
Economies of scale	Small						Large
Product Differentiation	Little						Big
Brand Identification	Low						High
Switching cost	Low						High
Access to distribution channels	Ample						Restric ted
Capital Requirements	Low						High
Access to Latest Technology	Ample						Restric ted
Access to raw materials	Ample						Restric ted
Government protection	Nonexist						High
Experience effect	Unimp- ortant						Very impt.

Large flat glass plants gain a cost reduction if a product is manufactured with high volume facilities and highly automated product lines, due to the high line speed and glasshandling requirements. This is the main reason for economies of scale and capital intensive investment, because any competitor with low-volume facilities and low automation would be at a competitive disadvantage.

A barrier to entry is the relatively small product differentiation combined with low switching cost. Brand identification is important, because the automobile's glass processing plant has a reputation for quality and delivery schedule. But for general glazing in the construction industry is largely irrelevant, unless it is related to a big building where response time is important. However, in this market segment the product differentiation is highly driven by the variety of colors of the coated film available for the surface.

Access to the latest technology is carefully protected by patents, secrecy, and industrial proprietorship, and in this manner all the incremental innovations of the process are well kept through confidential agreements, even from personnel in the organization. Another important factor connected with technology is the learning experience curve, since the continuous production process requires considerable practical skills and considerable depth of technical knowledge in each stage, beginning in the raw material area and continuing into the furnace area, glass-forming, annealing and the cold-end area where the glass is handled and stored. All these activities require high coordination and communication between the different functions.

The main threat is in the access to distribution channels and this should be carefully considered, due to the fact that distributors are more interested in better margins, technical support for big building contractors, fast and better service, and easy accessibility to reduce transport costs. This is especially attractive for glass importers since they can have a much easier access to the Mexican market.

Threat of New Entrants: Barriers to Exit

This refers to economic, strategic interrelationships, and intangible factors such as emotional barriers, as well as government and social restrictions, that keep firms competing in the industry, even though they may be earning low or even negative returns on investment. A very high exit barrier is a great contributor to the deterioration of industry attractiveness in mature and declining markets.

Figure 3.10. Barriers to Exit

Current oooooo Future ^^^^^^		Highly Unattra.	Mildly Unattra.	Neutral	Mildly Attract.	Highly Attract.	
Asset specialization	High	oooooooo ^^^^^^^^					Low
One-time cost of exit	High	oooooooo ^^^^^^^^					Low
Strategic interrelationship	High	ooooooooo ^^^^^^^^					Low
Emotional Barriers	High	ooooooooo ^^^^^^^^	ooooooo ^^^^^^^				Low
Government and social restrictions	High	ooooooooo ^^^^^^^^	ooooooo ^^^^^^^	^^^^^^^			Low

Analysis of the barriers to exit can reveal a mild to highly unattractive industry, because of the assets specialization, the cost of exit, and strategic interrelationship for vertical integration are very high in this industry. However as was mentioned, even the possibility of new entrants from a strategic view point, the emotional barriers play an important role as a major barrier to delaying the exit decision.

Availability of Substitutes

This force represents the threat from firms outside the industry that can offer substitutes which can either replace the current products or present an alternative to filling the demand and that could affect the attractiveness of the industry in different ways. I believe this force is difficult for me to evaluate objectively and my perspective is undoubtedly narrow or biased because of my personal love of the business after 25 years working in the company.

Figure 3.11. Availability of Substitutes

Current oooooo Future ^^^^^^		Highly Unattr.	Mildly Unattr.	Neutral	Mildly Attract	Highly Attract	
Availability of close substitutes	Large						Small
User's switching costs	Low						High
Substitute producer's profitability	High						Low
Substitute price/value	High						Low

I believe the industry is still very far from finding a material that can be a real threat as a substitute for flat glass from a commercial point of view. However, here the relative low user's switching costs could be a factor to watch in order to develop greater loyalty, and service is a key issue to consider in this dimension. In general the lack of a clear substitute makes this force attractive and no real changes can be seen in the near future.

Rivalry Among Competitors

This force represents the competition that the company will encounter in the industry as the result of interacting structural factors. Figure 3.12 lists these factors and ranks the degree of their effect on the industry. This dimension is clearly of interest both to potential new entrants in an industry, seeking to understand what lies ahead, and current market participants involved in changing the environment:

> *Intense rivalry among firms in an industry reduces average profitability. Large numbers of firms in a market reduce coordination opportunities. In general, in industries in which the major firms are all similarly sized, rivalry is more intense (Oster, 1994).*

Several authors in this field have mentioned that from this perspective, there are a number of industry characteristics that help determine the level of rivalry in the industry. To survive, a company has to be better than the best and be prepared to annihilate its opponents and destroy their power base, --the business world is tough and competitive.

Figure 3.12. Rivalry Among Competitors

Current oooooo Future ^^^^^^		Highly Unattr.	Mildly Unattr.	Neutral	Mildly Attrac	Highly Attrac	
No. of equally balanced competitors.	Large	oooooooo^^^^^^^	oooooooo^^^^^^^	oooooooo^^^^^^^	oooooooo^^^^^^^	ooooooo	Small
Relative industry growth	Slow	ooooooooo^^^^^^	ooooooooo^^^^^^	^^^^^^^			Fast
Fixed or storage cost	High	ooooooooo^^^^^^	ooooooo^^^^^^^				Low
Product features	Commodity	ooooooo^^^^^^^					Specialty
Capacity increases	Large increments	ooooooo^^^^^^^	^^^^^^^				Small increments
Diversity of competitors	High	ooooooooo^^^^^^	ooooooooo^^^^^^	ooooooooo^^^^^^	ooooooo^^^^^^^	ooooooo	Low
Strategic stakes	High	ooooooooo^^^^^^	ooooooooo^^^^^^	ooooooo^^^^^^^			Low

As mentioned earlier, there are no float glass manufacturing competitors in the country, but the players in the US have the capacity and technology to gain customers in the Mexican marketplace. On the other hand, the market share could be very volatile because there are no switching costs for the distributors, if they decide to change to another supplier, also, to some extent there is low customer loyalty, particularly for the end user and for some segments the buyer's decision is based on price, quality, and service.

I believe in the North American region there is an overcapacity, with minimum growth rates making it very unattractive to build new facilities in Mexico. However, it is highly attractive to import glass, due to the high financing costs in Mexico. This could be attractive for an importer, to have greater inventory with lower storage costs if it is financed in US dollars, the only high risk is the possible devaluation of the Mexican peso.

At present there is more product variety in reflective glass for buildings in the US market, and this fact is very attractive for the Mexican consumers and consequently for glass imports, thus offering a good positioning in this market segment.

As the tariff barriers fall, I would guess that rivalry in the Mexican market will increase. It is important to bear in mind that today strategic alliances represent one of the key actions for business development, and this can be the natural course of action for a foreign company to gain access to the market. But, on the other hand it also could mean agreements among competitors with conflicting interest and the sharing of common objectives to eliminate or significantly reduce confrontation among them. There are various examples of this type of relationship for global strategic alliances, e.g., in the automotive industry, and the alliance between Fuji Films and Rank Xerox to create Fuji Xerox, that today is one of the world's largest copy machine manufacturers.

The Power of Buyers

The power of buyers is a force that can be gradually increased as more import glass reaches the market and the competition increases; therefore the company needs to pay more attention to what the customers want. Here an important factor to consider is the current small number of large distributors and the contribution of their purchases to the total sales of the company. Glass as a commodity increases the power of the buyers since it typically reduces the switching costs of those buyers and allows them to more easily play one supplier against a second as already happened with at least one of those large distributors.

Figure 3.13. Power of Buyers

Current oooooo Future ^^^^^^		Highly Unattr.	Mildly Unattr	Neutral	Mildly Attrac	Highly Attrac	
Number of important buyers	Few						Many
Availability of substitutes for industry products	Many						Few
Buyer switching costs	Low						High
Buyers' threat of backward integration	High						Low
Contribution to quality or service of buyers' products	Low						High
Total buyers' cost contributed by the industry	Large fraction						Small fraction
Buyers' profitability	Low						High

There are few important buyers, therefore the power applied by them affects the company by asking for better price or margin, service, and technical support. Service is oriented to short delivery time, easier accessibility, and more diversity of reflective glass (coated); technical support means better, quicker and wider support to their customers for more sophisticated applications. The low switching costs for buyers is a critical factor

to monitor because as more import glass is available in the market the greater will be the threat to change supplier. This means more imports direct from US manufacturers or requests for a better price and other conditions.

The Power of Suppliers

The suppliers have very similar effects as buyers on the industry, and as we will see, the same factors that determine the power of buyers also determine the power of suppliers. Suppliers can utilize their bargaining power by increasing prices or reducing the quality of purchased goods and services. Powerful suppliers can therefore reduce the profitability of an industry that is unable to transfer the increased costs to its customers Also the more open information is in the industry, the less power will be held by suppliers. However, it is important to remember the lesson given by Japanese firms on the significance of treating suppliers as central partners, whose relationship has to be nurtured and strengthened, so as to become an extension of the company itself.

Figure 3.14. Power of Suppliers

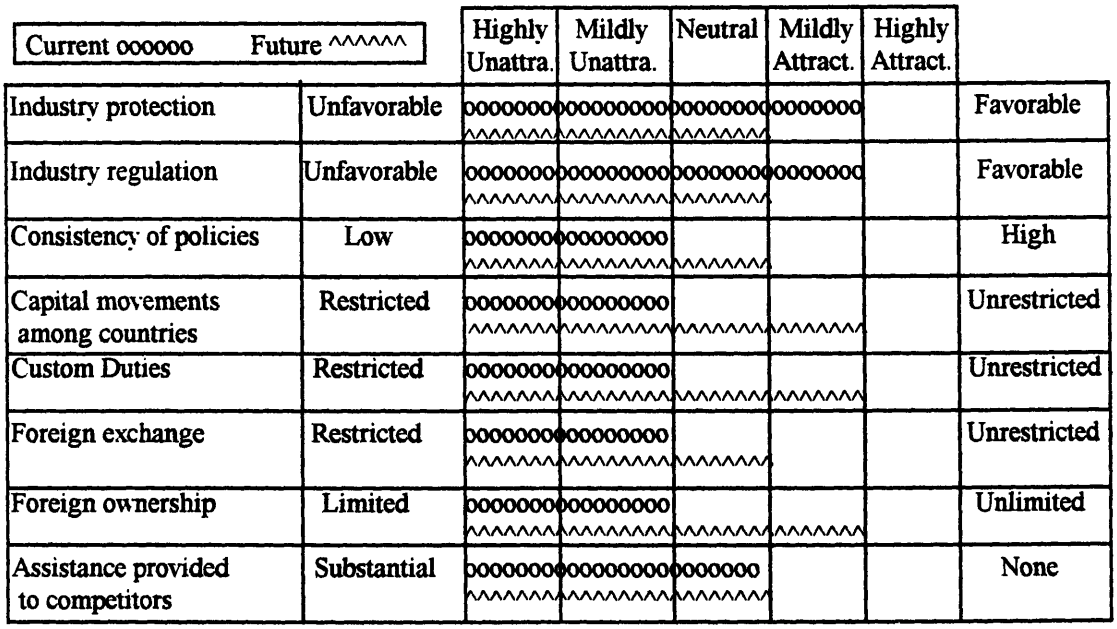
Current ooooo Future ^^^^^		Highly Unattr	Mildly Unattr	Neutral	Mildly Attrac	Highly Attrac	
Number of important suppliers	Few						Many
Availability of substitutes for the suppliers products	Low						High
Differentiation or switching costs of suppliers' products	High						Low
Suppliers' threat of forward integration	High						Low
Industry threat of backward integration	Low						High
Suppliers' contribution to quality or service	High						Low
Total industry cost contributed by the suppliers	Large fraction						Small fraction
Importance of the industry to suppliers' profit	Small						Large

Switching costs for a product supplier are high because the raw materials and primary supplies are highly specialized for the flat glass industry and for that reason there are also few suppliers. The company is highly vertically integrated with its main suppliers in Mexico, although not as much as happened in the US. The forward integration of outside suppliers in Mexico is very low; in the US the maturity of the market and its installed over-capacity is a fact that keeps this possibility unattractive.

Government Actions

As was mentioned before, the industry in general can be influenced by government actions, affecting all the forces in Porter's model, factors such as: industry protection and regulation, policies, foreign exchange and custom duties. The following figure shows the different dimensions of this force:

Figure 3.15. Government Actions



All these factors have been changed in Mexico with the implementation of NAFTA, and commercial trade barriers among the North American countries have decreased in recent years and should continue. On the other hand, solid waste management and recycling concerns will increase the government's protection of the flat glass industry in the future, particularly in the main cities where the larger markets are located. In general it can be said:

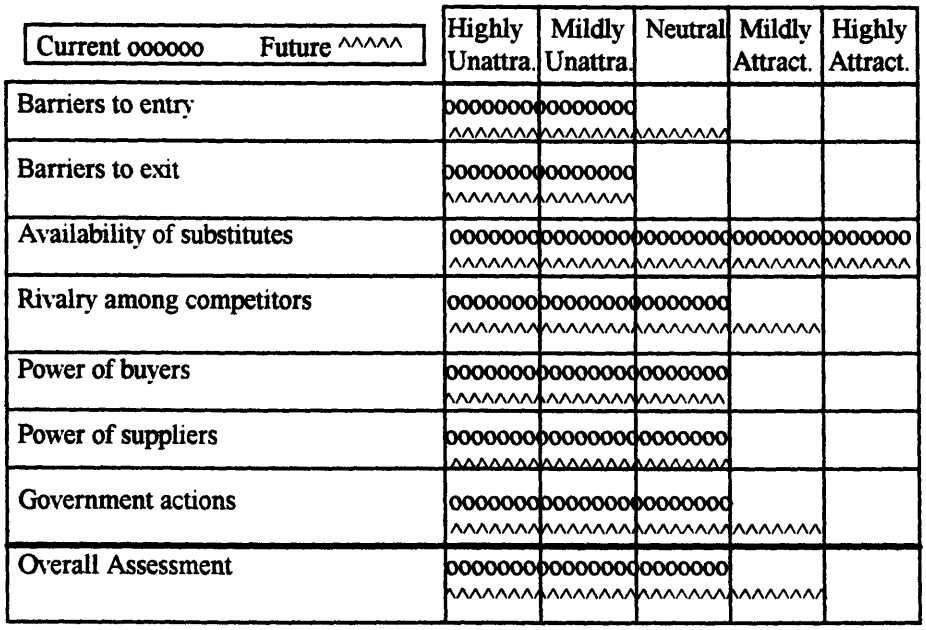
> *Regulation may have a dramatic effect on rivalry within an industry. Antitrust laws attempt to increase firm rivalry. Government actions can determine industry profitability (Oster, 1994)*.

In general government actions tend to be more clear and aligned to international policies, and in consequence could be either favorable or at least not interfering with business activities.

Overall Assessment

The Figure 3.16 illustrates each one of the seven forces analyzed before giving a concluding attractiveness rating based on Porter's model.

Figure 3.16.- Overall Attractiveness Assessment



The current overall assessment of the industry is **NEUTRAL**. This is due to the high barriers to entry and to exit, which means that there is low attractiveness. Rivalry among competitors is considered to be neutral, because its tendency is to increase and make the industry mildly attractive. In addition there is no close substitute, which make the industry very attractive. The overall assessment of industry attractiveness is expected to shift from **NEUTRAL TO MILDLY ATTRACTIVE**.

3.4 ANALYSIS OF EXTERNAL FACTORS

This analysis refer to external factors that are out of the company's control and Hax and Majluf in their methodology have found it useful, to identified those critical factors considered to be the central determinants of industry attractiveness. Management should focus on forecasting changes in the industry's external factors and the influence those changes will have on the company itself. Unlike Porter's model, which is based on a set of fixed elements grouped as forces anchored on industrial organization principles, this model identifies external factors that are particularly relevant to the industry and their future trends in which the business competes.

Hax and Majluf provide a set of factors that are broken into five major categories: market, competitive, economic and governmental, technological, and social. I will present only an assessment of the market and technological factors, as they relate to current conditions in the Mexican industry.

Figure 3.17. External Factors

Current oooooo Future ^^^^^^			Highly Unattra.	Mildly Unattra.	Neutral	Mildly Attract.	Highly Attract.	
FACTORS	SELECTED INDICATORS							
MARKET	Market size	L						Hi
	Market growth rates	L						Hi
	Price sensitivity	Hi						L
TECHNOLOGY	User's switching costs	L						Hi
	Industry profitability	L						Hi
	Maturity	Ag						Gr
	Patents & access to technology	L						Hi
	Product R&D requirements	L						Hi
	Process R&D requirements	L						Hi
	Level of service required by customers	L						Hi

Analysis of the market factor indicates that there are some favorable trends affecting the flat glass market in Mexico, but this will be influenced as NAFTA goes into effect and other Latin American countries are involved. Also, the potential market growth is heavily affected by the construction and automotive industries whose development depends in the country's GDP. However, it is important to make the following points:

- Moderate market growth in the near future.
- High price sensitivity with lower industry profitability.
- Requirements for more reliable service: faster delivery time, flexible freight volume, technical support and closer relationships.

Regarding the technological indicators in this mature industry, the clear tendency exists for continuous improvement and incremental process innovations to increase productivity and lower production cost. Nevertheless, there is a more intensive use of information technologies and higher levels of investment without necessarily allowing for sustainable differentiating opportunities among the various players. It is also important to keep in mid, that there is always room for improvements and radical innovation, as was established in the previous chapter.

Some important issues will have an effect on middle and long-term productivity, production costs, and technological changes:

- Possible major innovation in glass melting, due to environmental and energy conservation policies, such as oxygen enrichment, electric boosting, etc.;
- Continuation of new product development in the reflective glass process;
- Requirements for better thermal glass performance due to the increased energy conservation policies and the architectural design of new buildings. People are now paying more attention to the environment and their surroundings;
- Increased need for glass recycling due to strong pressure from environmental control groups, also a trend to reduce raw materials cost;

- Developments in building technology that may affect glass utilization and customers' needs in this segment;
- More capital for R&D requirements, but more effective and measurable work;
- Continuous improvement in glass melting and forming for better quality and lower cost to defend competitive position.

All these factors emphasize the strategic role of technology for the company to help grow the business and sustain or improve its competitive position by extending the range of products and their applications, extending the differentiation potential of products, or focusing on cost reduction. This implies a better integration of business and technology strategies and the operational principles for a wider implementation that make the process really work. In other words it will be necessary to develop know-how that can be translated into management action toward products, processes, cost reduction, quality improvements, conformance with environmental regulations, support for product claims, a clear orientation toward customer service, and an increased understanding of future customer needs in order to remain ahead in product development.

After the final overall industry assessment, the goal is to extract from Porter's analysis and from the external factors evaluation the key opportunities emerging from the favorable factors affecting the industry; and the key threats resulting from the adverse impact to industry attractiveness.

- **Key Opportunities:**
  - Brand recognition is an important factor in the international market.
  - Economies of scale, high asset specialization, and low number of competitors in the global market could lead to oligopolistic opportunities.
  - The distribution experience acquired through the US subsidiary should be used to leverage access to prominent distribution channels in Mexico and Central America via possible partnerships.

- Improvements in productivity and focus on cost reduction in the traditional basic product to become the customer's first choice.
- Growing consumer awareness on increased thermal performance for energy conservation and architectural surroundings, bringing opportunities for new product development in reflective glasses.
- Development of an IT system as a tool for integrating technology, marketing and training in order to increase innovation capacity and product development.

- **Key Threats:**
  - Low end consumer loyalty and low switching costs.
  - New requirements for integrated design and glass utilization for future building technology. Service provided with the product?
  - NAFTA and deregulation have allowed glass imports, and consequently more competition from U.S. manufacturers and possible partnerships in distribution channels.
  - Margins and profits tend to deteriorate.
  - Increased power of the distribution channel, greater bargaining power of buyers
  - Increase in environmental concerns and regulations, strong pressure.

3.5 INTERNAL SCRUTINY

As indicated in Chapter 1, there are two analyses needed to determine the competitive position of the business, that serve as a support tool for stating the action plans. First is the environmental scan to measure the attractiveness of the industry, both now and in the future. The other dimension is the internal scrutiny, which is the analysis of the firm's position with respect to controllable factors for achieving competitive superiority. The goal is to identify the critical success factors and their analysis leads to

defining the major strengths and weaknesses of the business against its most significant competitors. The methodology suggested by Hax is supported in the basic concepts of the value chain that are thoroughly explored by Porter's model (1985), in a systematic and disciplined approach to guiding a manager through all the necessary steps to perform the internal scrutiny at the business level.

Because competitors are the basis for assessing competitive standing, there are two different ways to select the relevant competitors:

1).- From a market point of view:

-It has a high market share.

-It has experienced a sustained market growth.

-It earns high levels of profitability with regard to the industry average.

-It has demonstrated an aggressive competitive attitude against VVP business or some important segment.

-It has a highly vulnerable position against VVP competitive actions.

2).- From a functional point of view:

-It has the lowest cost structure.

-It has the strongest technical base.

-It has the strongest marketing.

-It offers the best product quality.

-It shows the highest level of vertical integration.

-It exhibits the highest level of capacity utilization.

• Assessing the Competition. No real competitor to VVP exists in Mexico. There are two small glass manufacturers who use the old vertical drawing process with very inconsistent operation and low glass quality. However, with the NAFTA implementation, the integration of the North American market brings some serious threat from US competitors. These competitors should be taken into account in the business strategy in order to achieve a sustainable advantage over them.

It is very important to collect as much quantitative and qualitative information to construct a well-rounded overall competitive profile, and the diagnosis should be done with one competitor at a time. In this case the analysis is done taking in account only limited qualitative information and, as noted earlier, these assessments represent the subjective judgment of the author.

The main US glass manufacturing competitors are: PPG Industries, Glass Division; Guardian Industries Inc.; and LOF Co. The degree of weakness and strength is only rated against PPG Industries for each of the critical success factors. Due to reasons of confidentiality, I have not included the comparison with all the competitors and also some values have been changed. What is presented is an important exercise in the methodology --the overall ranking for all the competitors.

Step One:

The first step is to select the critical success factors that identify the competitive skills that are the foundation for determining the company's position in the industry. The methodology suggested by Hax (1995) recommends classifying the activities of the value chain into seven different categories which are slightly different than those proposed by Porter:

- Managerial Infrastructure.
- Technology.
- Manufacturing.
- Marketing and Sales.
- Human Resources Management.
- Finance.
- Procurement.

These factors allow the identification of key strengths and weaknesses, and thus specific actions at the SBU level. Figure 3.18 summarizes each category[4] that will be used to determine a competitive profile. However, when implementing this phase in a real situation, this list should be modified to fit the particular circumstances of the business unit.

[4] For more comprehensive list of attributes for the different seven categories and further details of the selection of critical success factors, refer to A. Hax working manuscript, (1995).

Figure 3.18. Identification of Critical Success Factors.

Category	Comments
*Managerial Infrastructure	Includes the administrative processes of the firm, covering all the issues related to developing corporate values, organizational structure, planning and coordination, managerial and leadership capabilities. Furthermore the corporate culture and corporate image are relevant elements in assessing the competitive profile.
*Technology	Is one of the central functions in achieving competitive advantage, because we are living through a period of fast-paced technological transformation. Technology intelligence is essential to gather information on the dynamics of technological changes and market needs.
*Manufacturing	This function is clearly interfaced with other functions and requires a certain reiteration of issues that may well be considered in the realm of other functions, but they are also central for manufacturing, and careful process of internal management must be addressed.
*Marketing and Sales	These two functions as well as service is clearly oriented toward the satisfaction and understanding of customers' needs, new necessities, and the triggering of purchasing behavior. Includes all the logistic of distribution and the after-sale services.

Source: adapted from Hax, 1995

Step Two:

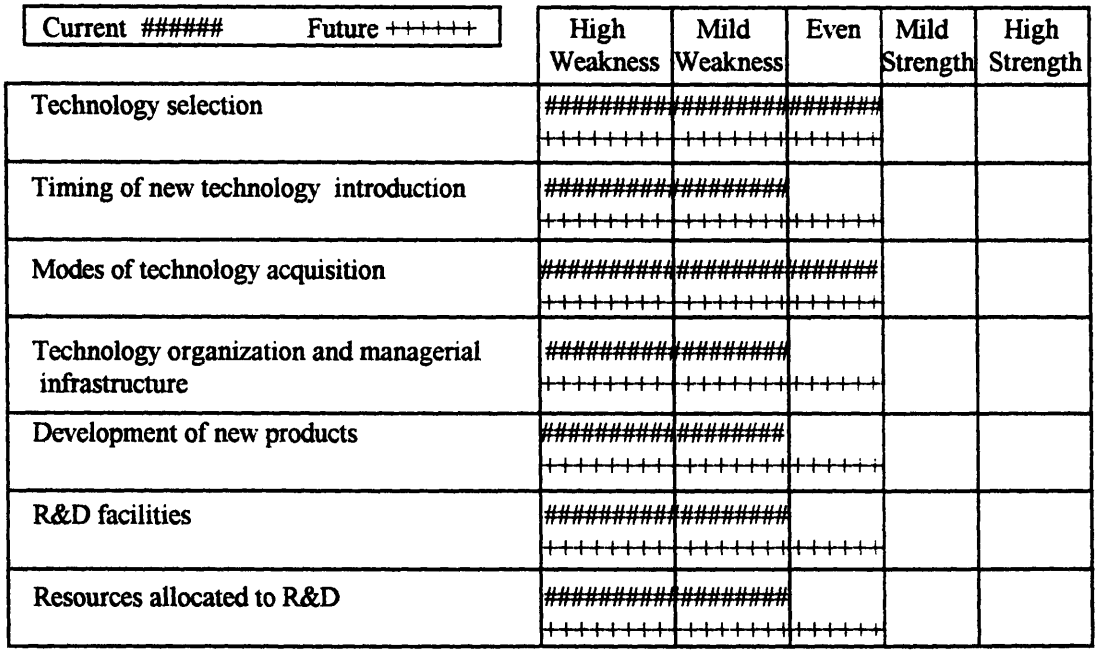
Figures 3.19 to 3.22 show the competitive profile of VVP against PPG, one of its toughest competitors using the four categories of critical success factors outlined earlier. This kind of comparison can be a dynamic tool for monitoring the competition and it must be continually updated.

Figure 3.19. Competitive Ranking of Managerial Infrastructure -VVP vs. PPG-

Current ###### Future ++++++	High Weakness	Mild Weakness	Even	Mild Strength	High Strength
Planning system	######## ++++++++	######## ++++++++	######## ++++++		
Communication and information system	######### +++++++++	######## ++++++++	++++++		
Organizational structure	######### +++++++++	######## ++++++++	######## ++++++		
Corporate culture	######### +++++++++	######## ++++++++	######## ++++++		
Leadership capabilities	######### +++++++++	######## ++++++++	######## ++++++		
Corporate image	######### +++++++++	######## ++++++++	######## ++++++	######## ++++++	

Regarding managerial infrastructure, the strengths of VVP and PPG are fairly equal, however, it is important to improve VVP's communication and information system as the North American market is progressing rapidly in its implementation; particularly taking advantage of the subsidiary in United States.

Figure 3.20.- Competitive Ranking of Technology -VVP vs. PPG-



VVP has some disadvantages against PPG in the management of technology. Significant emphasis is placed in improving the development of new products, particularly in reflective glass. A major effort should made to improve the strategic timing of new technology development and introduction of new products.

Figure 3.21.- Competitive Ranking of Manufacturing -VVP vs. PPG-

Current ###### Future ++++++	High Weakness	Mild Weakness	Even	Mild Strength	High Strength
Location and number of plants	######## ++++++++	######## ++++++++	######## ++++++++	######## ++++++++	
Capacity	######## ++++++++	######## ++++++++	######## ++++++++		
Manufacturing organization and managerial infrastructure	######## ++++++++	######## ++++++++	######## ++++++++		
Vertical integration	######## ++++++++	######## ++++++++	######## ++++++++		
Supplier relations	######## ++++++++	######## ++++++++	######## ++++++++		
Capacity utilization	######## ++++++++	######## ++++++++	######## ++++++++		
Product scope and introduction of new products	######## ++++++++	######## ++++++++	++++++++		
Unionization	######## ++++++++	######## ++++++++	######## ++++++++	######## ++++++++	

VVP has the great advantage of the location of its plants in Mexico and the unionization of its workforce. However it has a slightly less responsiveness in the timing of new products, where significant emphasis is being placed and a delicate coordination process for functional interactions should be addressed.

Figure 3.22. Competitive Ranking of Marketing and Sales -VVP vs. PPG-

Current ####### Future ++++++	High Weakness	Mild Weakness	Even	Mild Strength	High Strength
Defining and analyzing markets	######## ++++++++	######## ++++++++	####### ++++++		
Product strategy	######## ++++++++	######## ++++++++	 ++++++		
Distribution strategy	######## ++++++++	######## ++++++++	######## ++++++	######## ++++++	
Promotion and advertising strategies	######## ++++++++	######## ++++++++	 ++++++		
Location and number of warehouses	######## ++++++++	######## ++++++++	######## ++++++	######## ++++++	
Marketing capabilities	######## ++++++++	######## ++++++++	 ++++++		

The competitive position of VVP against PPG shows that VVP has a strong distribution network, with a much better logistical knowledge of the market. However, PPG enjoys an advantage in its marketing capabilities, VVP should take action to achieve a better level of performance.

Step Three:

After a competitive profile based on the same four factors has been completed for each relevant competitor, it is possible to rank all the competitors.. This exercise develops a strong base from which to catalog VVP's own strengths and weaknesses. After the assessment and ranking of all competitors, the next step is to summarize the overall competitive position of VVP against each of its most relevant competitors for each category selected in the critical success factors. Figure 3.23 illustrates such an overall ranking against PPG.

Figure 3.23. Summary of the Competitive Assessment -VVP vs. PPG-

Current ###### Future ++++++	High Weakness	Mild Weakness	Even	Mild Strength	High Strength
Managerial infrastructure	######## ++++++++	######## +++++++	######## ++++++		
Technology	######## ++++++++	######## +++++++	++++++		
Manufacturing	######## ++++++++	######## +++++++	######## ++++++	######## ++++++	+++++++
Marketing and Sales	######## ++++++++	######## +++++++	######## ++++++		
Overall Assessment	######## ++++++++	######## +++++++	######## ++++++		

It can be seen that VVP has a leading capability in manufacturing, and this could be stronger as productivity and cost reduction progresses. However, in the technology factor there is some weakness. The timing of new technology introductions and new product development plays a relevant role, intimately related with marketing intelligence.

Step Four:

After completing the internal scrutiny, the next step is to provide a statement of strengths and weaknesses of all the competitors as they relate to VVP. This should indicate VVP's current and future competencies, as well as the issues to be addressed by VVP to either neutralize its competitors strengths or exploit their weaknesses. A final list can the be established of the strengths and weaknesses that are most significant for VVP. c As noted earlier, these assessments represent the subjective judgment of the author.

Strengths and weaknesses of PPG:

STRENGTHS
• PPG is the leading company in the US market. • It has a good managerial infrastructure. • It has a strong R&D capabilities. • It offers a greater variety of reflective products than VVP. • PPG has numerous patents. • It has strong brand recognition and marketing link.
WEAKNESSES
• PPG lacks knowledge of Mexican market and distribution channels. • Transactional currency exposure on price and profits.
ISSUES TO BE ADDRESSED
• PPG has good R&D capabilities and marketing link. • PPG has experience in international joint ventures. • Is ahead in global operations.

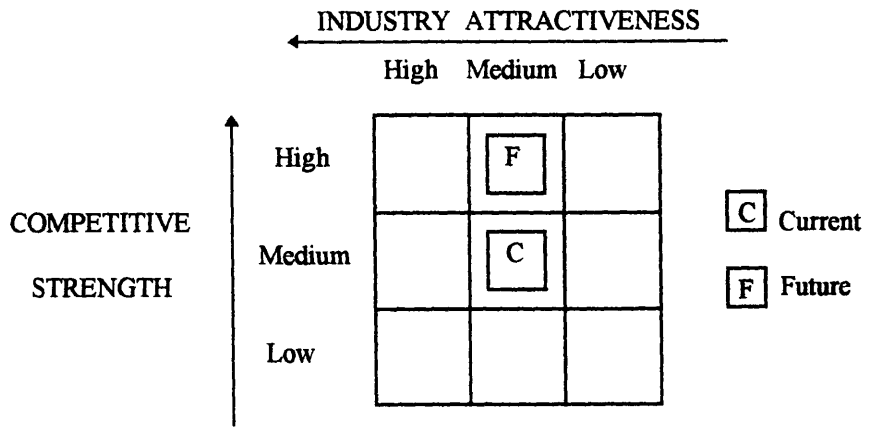
Strengths and weaknesses of VVP:

STRENGTHS
• High quality products. • VVP has an established warehouses across the country. • Strong links with distribution channels. • It has a strong public image. • It has good price competitiveness. • VVP offers customers' technical support. • It has a highly skilled workforce.
WEAKNESSES
• It has smaller R&D capability than PPG. • Low rate of new products introduction. • Poor integration of IT as managerial tool. • Weak personnel commitment and ownership.

3.6 POSITIONING IN INDUSTRY ATTRACTIVENESS-BUSINESS STRENGTH MATRIX

In order to summarize the analysis done in the previous section, it is useful to create an Industry Attractiveness-Business Strength matrix, which is presented in Figure 3.24. This matrix positions the SBU according to two critical dimensions: one is the external dimension, industry attractiveness, which attempts to capture the overall attractiveness of the industry in which the business participates. The second is the internal dimension, business strength, that represents the assessment of the company's strength based on the critical success factors, and defines the competitive position of the business within the industry.

FIGURE 3.24. Industry Attractiveness-Business Strength Matrix



GENERIC STRATEGIES ASSOCIATED FOR	
CURRENT	Identify growth segments, specialize, invest selectively.
FUTURE	Identify growth segments, invest strongly, maintain position elsewhere.

BUSINESS STRATEGIC PRIORITIES
Maintain Selectively: The business has a good position in an industry that is getting less attractive (commodity), but there are situations to exploit.

3.7 BROAD STRATEGIC ACTION PROGRAMS

Having completed the external and internal analyses, what follows is a well-coordinated set of action programs which should enhance VVP's current position and secure a long-term sustainable competitive advantage. The business programs are defined at two different levels of specificity: broad action programs that typically represent the long-term strategic objectives; and specific action programs which

represent the tactical support needed in the short term, for the realization of strategic objectives. Furthermore, the result of the business strategy can be translated into a budget, which is the bridge between the strategic planning process and the management control process.

In the following, only broad action programs are defined. The more detailed level of specific programs and budget have not been developed in this thesis owing to difficulty in gathering detailed information due to confidentiality reasons. The broad action programs are defined taking into consideration the requirements imposed by the three major pieces of the previous analysis:

1).- the challenges emerging from changes in product, market, and geographical scopes, and unique competencies;

2).- the opportunities and threats from the environmental scan and;

3).- the strengths and weaknesses from the internal scrutiny.

ACTION PROGRAM #1

Integrate marketing strategies to consolidate and expand geographical penetration by increasing market share in the defined countries.

Key indicator for management control: Growth of market share and sales.

First major milestone description: Sales volume increase in 1995 in those defined countries.

ACTION PROGRAM #2:

Expand the sales plan in the maquila industry, decorators, and retailers segments to strengthen the competitive position and creating entry barriers.

Key indicator for management control: Growth in sales in those segments.

First major milestone description: Concrete action plans for each segment.

ACTION PROGRAM #3:

Develop a technology framework to generate core competencies and establish internal mechanisms for improving technology transfer and assimilation process.

Key indicator for management control: More people involved and R&D cost.

First major milestone description: December 1995, plan and policy in place.

ACTION PROGRAM #4:

Develop strong capabilities for manufacturing reflective glasses.

Key indicator for management control: Number of products introduced.

First major milestone description: Market research plan to identify the products, their applications and definition of R&D plan.

ACTION PROGRAM #5:

Develop programs of productivity to optimize the use of resources and achieve position of low cost producer and integral customer service leadership.

Key indicator for management control: Benchmarking and target indicators.

First major milestone description: Document describing main indicators and date for approval of the plan.

ACTION PROGRAM #6:

Develop applications of the information technology system to serve business needs and create a business competitive advantage.

Key indicator for management control: Number of links and useful access.

First major milestone description: Definition of information requirements at different levels, in order to achieve the operational and strategic business goals.

These broad action programs are presented below connected with the outcome of the analyses done for the three fundamental elements of a business strategy.

LINKAGES OF BROAD ACTION PROGRAMS FOR VVP	Action Program Number					
	#1	#2	#3	#4	#5	#6
• **Challenges emerging from product scope:**						
To expand production capacity to other float units for the reflective on-line process to gain manufacturing flexibility.				■	■	
Focus greater effort on the reflective off-line technology and product development, considering its versatility to meet the increased trend in energy conservation and aesthetic architectural requirements.			■	■	■	
To increase the penetration of the rolled plate glass as a decorative element with the assessment of new more attractive patterns..		■	■		■	
Focus explicitly on the potential growth requirement for developing a technology which economically reduces or eliminates the need for cleaning glass.			■			■
• **Challenges emerging from market scope.**						
Intensify marketing efforts to increase customers via small dealers and medium retailers	■	■				■
Target the maquila industry to increase market share.		■				■
Target the decoration/interiors market with specific marketing efforts. These are not necessarily commodity products.	■	■				■
Develop a strategy to assess the fenestration market due to increasing industrialization, off-site fabrication, large facade components, new methods of assembly and factory fabrication			■			■
• **Challenges emerging from geographical scope.**						
Develop a strong position in the American market, using basic products through the US subsidiary.	■				■	
Develop alliances for distributing the basic products in Central American countries	■					■
Develop strong position and loyalty in the distribution channels for the domestic market.		■			■	
• **Challenges emerging from unique competencies (Technology)**						
Develop appropriate technical skills in the off-line reflective proc.			■	■		
Develop an integrated information technology for an effective management practice.			■			■
Improve the mechanism for integrating outstanding teams to intensify product development and innovation.			■		■	
Evaluate and define the policy for resources allocated to R&D.			■			■
Develop a company image of an environmentally safe company that is ecological aware.						■
Develop market intelligence and tighten relations with production and R&D.			■			■

	Action Program Number					
	#1	#2	#3	#4	#5	#6
• **Key Opportunities:**						
Brand recognition is an important factor to in the international market.	■					
Economies of scale, high asset specialization, and low number competitors in the global market could lead to oligopolistic opportunities.	■	■				■
The distribution experience acquired through the U.S. subsidiary should be used to leverage access to prominent distribution channels in Mexico and Central America via possible partnership	■					■
.Improvements in productivity and focus on cost reduction in the traditional basic product to become the customer's first choice.					■	
Growing consumer awareness on increased thermal performance for energy conservation and architectural surroundings, bringing opportunities for new product development in reflective glasses.			■	■		■
Development of an IT system as a tool for integrating technology, marketing and training in order to increase innovation capacity and product development.			■			■
• **Key Threats:**						
Low end consumer loyalty and low switching costs.	■	■			■	
New requirements for integrated design and glass utilization for future building technology.			■			■
NAFTA and deregulation have allowed glass imports, and consequently more competition from U.S. manufacturers and possible partnerships in distribution channels.		■			■	■
Margins and profits tend to deteriorate.					■	
Increased power of the distribution channel, greater bargaining power of buyers	■	■			■	
Increase in environmental concerns and regulations			■			■
• **STRENGTHS**						
High quality products.	■	■			■	
VVP has an established warehouses across the country.		■			■	
Strong links with distribution channels.	■	■				
Strong public image.	■	■				
Good price competitiveness.	■	■			■	
VVP offers customers' technical support.	■	■				■
Highly skilled workforce.	■	■				
• **WEAKNESSES**						
Smaller R&D capability			■			■
Low rate of new products introduction.			■			■
Poor integration of IT as managerial tool.						■
Weak personnel commitment and ownership			■		■	

CHAPTER FOUR

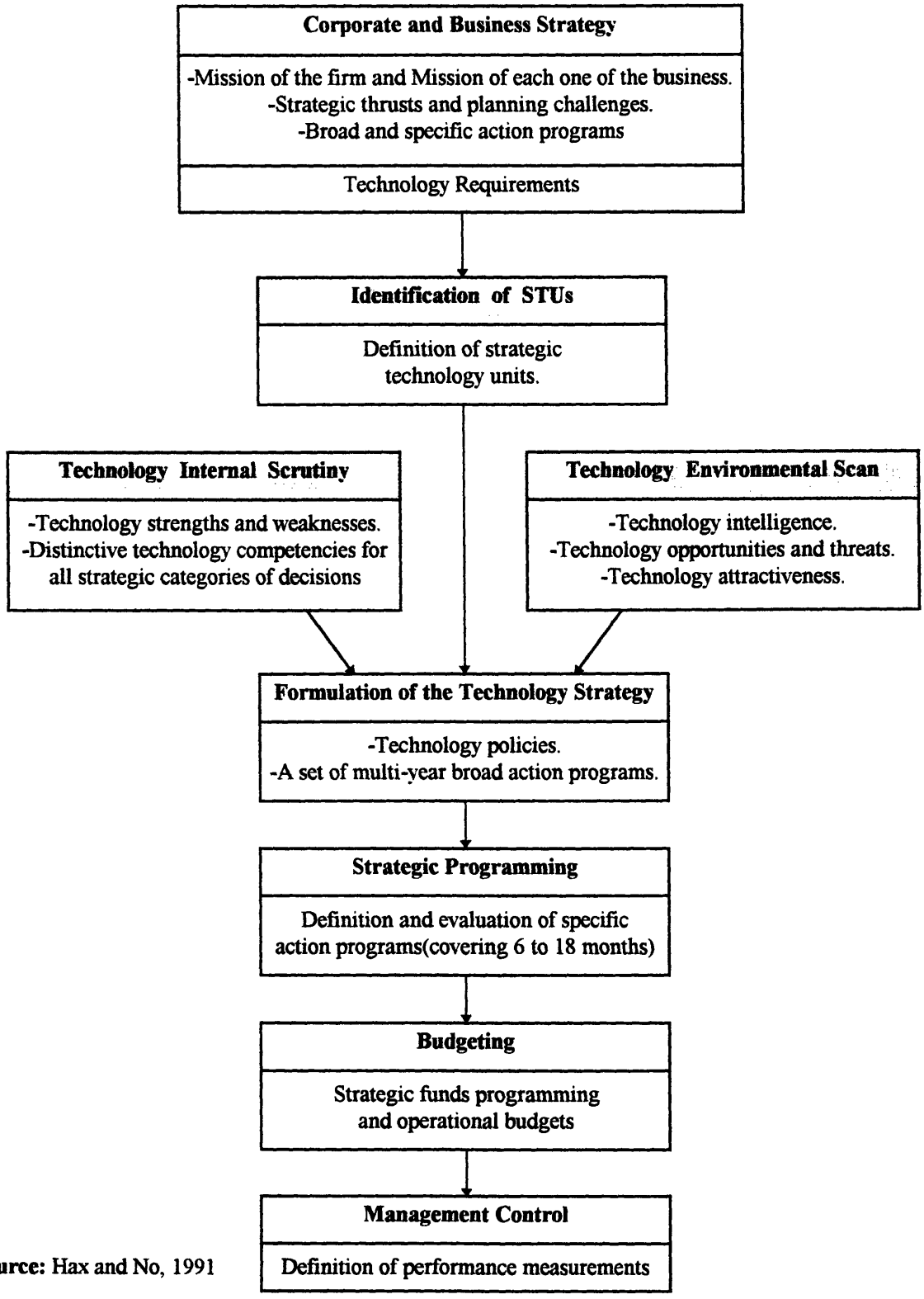
TECHNOLOGY STRATEGY

This chapter focuses on the technology strategy, since technology is one of the main methods of acquiring competitive advantage. For the purpose of this thesis, technology can be defined as those tools, devices, and knowledge that mediate between inputs and outputs -- process technology -- and/or that create new products or services --product technology -- (Rosenberg, 1972). Technology also enables a company to say: "We know how to apply science or engineering to..., in a way that clarifies what the technology does for the business instead of just stating what the technology is" (Roussel et al, 1991). With this definition, science and engineering are embedded in the product or process by technology.

The successful management of technology will link technology strategy to the business strategy of the company. The elements of business strategy that communicate the technological requirements more clearly are synthesized into the mission of the firm, particularly in the product scope and the statement of unique competencies. These are the main issues the firm must address in order to establish a strong competitive advantage (Hax and No, 1993). In formulating the technology strategy, the primary tasks follow closely those displayed at the business level, (refer to Figure 4.1). The mission statement of the firm, with the current and future products scope and unique competencies, provide the initial input; and in addition, the broad action programs offer more detail to support the objective of the firm.

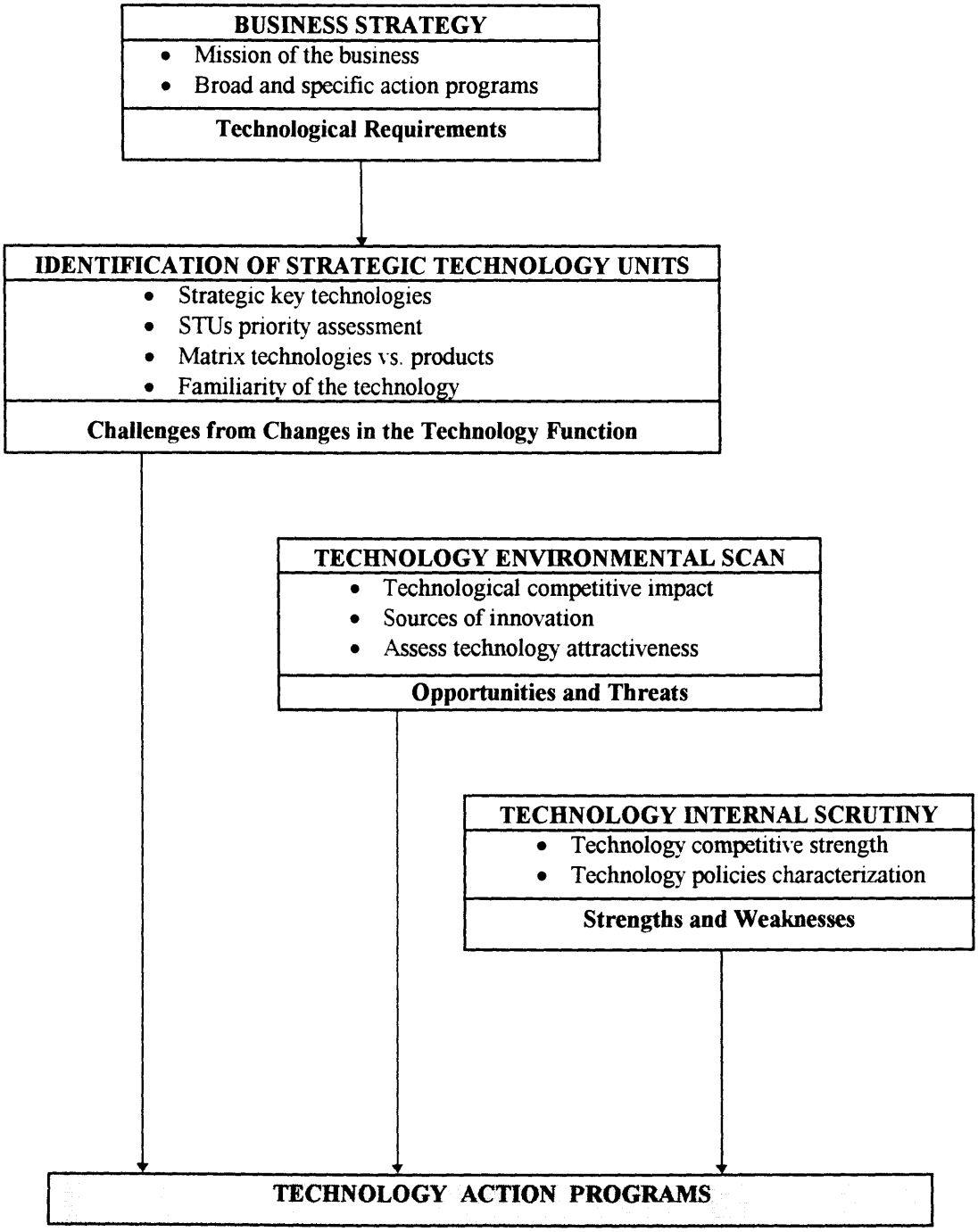
Figure 4.2 illustrates the main sources of information and the major tasks required for developing the technology strategy. The top four boxes represent the sources of information needed to formulate the strategy, using technology as a source of competitive advantage. The essence of any business strategy is trying to be different, separating the company from its competitors rather than imitating them; this creates a genuine claim for business leadership. I will use only some of the techniques to gather the information needed to form a technology strategy, but the management of the company will need to choose what is best for the technologies involved.

FIGURE 4.1. A Framework for the Development of Technology Strategy



Source: Hax and No, 1991

FIGURE 4.2. Sources of Information for Technology Strategy



The first step in developing technology strategy is to identify the technological requirements implied by the business strategy. The second step is to identify the portfolio of specific key technologies the firm is using or will be using to support its business. The third step is the environmental scan, which helps identify the external trends of the technology. The outcome of the scan will identify the key opportunities and threats for the technology function. The last step is the internal scrutiny, which tries to identify the technology's competitive position against its competitors with the goal of establishing the strengths and weaknesses of the firm itself. The final outcome of building the technology strategy is a set of action programs for the technology function that enable the firm to achieve superior competitive performance.

4.1 TECHNOLOGICAL REQUIREMENTS

The technological requirements have to represent the addition of the entire set of requirements imposed by the business unit. As technology is a function that, in general, cuts across all the business units, its strategic effect comes from among other things, a synergy effect generated by the cross-business, cross-function of the technological activities and resources. It creates a common understanding between top management and the technical function and establishes an effective linkage between the business and technology strategies.

In developing the technological requirements, management has to pool together the set of requirements outlined by the SBU. The final outcome has to be a clear, defined statement of coherent requirements that the firm as a whole place upon this function. Figure 4.3 shows the technology requirements of the business strategy.

FIGURE 4.3. Technological Requirements

Technology Requirements of the Business Strategy
• Develop an information technology system for an effective management practice, and create a business competitive advantage. • Set the appropriate tools for technology transfer and assimilation process among the RD&Engineering, Manufacturing, and Marketing operations. • Enhance and develop the core technologies needed for reflective glass processes and the introduction of new products. • Assess the long-term performance requirements for the use of glass as an integrated system in the construction industry (fenestration, facades, etc.) for glazing, and the needs of glass cleaning media. • Improve manufacturing capabilities to increase productivity and ensure performance as a low-cost manufacturer. Promote personnel commitment and ownership.

4.2 IDENTIFICATION OF STRATEGIC TECHNOLOGY UNITS (STUs)

The proper selection of a firm's strategic technology units (STUs) is one of the most critical elements, as well as difficult in the methodology for developing the technology strategy. These technology units are a planning tool used to shape the strategic response to the previous technological requirements. An STU refers to a discrete technology or group of technologies that are used by the company; a very broad definition causes unnecessary dispersion of technological resources and frequently leads to a loss of technological leadership.

A strategic technology unit is a specific set of technological expertise and activities in which a company should participate in order to achieve and maintain superior competitive performance. To be effective in this task, it have been established in the present methodology that any STU should:

- Be broad enough in order not to leave out potential innovations, yet specific enough so as to allow a clear understanding of the technological position of the company.
- Develop continuity, because it will exist over a relatively long period of time in order to develop expertise and management control. This does not preclude the underlying product and process technologies included in a given STU to evolve through time.
- Be critical to the product or service. It is recognized as a potential source of competitive advantage.
- Require a set of distinctive technical capabilities. Each STU will represent a unique contribution, (Hax and No, 1993).

The STUs do not generally conform with any company structure. The technology function is much broader than the R&D or Engineering or Manufacturing department, and has a crucial role in the strategy of the entire company. It is important to differentiate between technologies related to the products, technologies related to the processes, and those related to organizational aspects.

The following list presents the STUs identified in the case of VVP, as key technologies:

1.-Product characterization:	Technologies related to the assessment of the optical and physical properties of the products.
2.-Glass reflective processes:	Technologies relating to glass surface chemistry for film coating by pyrolisis and high vacuum, as well as surface protection.
3.-Process instrumentation:	Technologies associated with the measurement instruments for process parameters.
4.-Fenestration technology:	Technologies related with building design, where electronic display built into glass can play a key role in building construction "intelligent building".

5.-Process technologies:	Systems to support the procurement, control of suppliers, new raw materials, and manufacturing operations for continuous improvement.
6.-Information technology system:	Information system to support technology management, marketing intelligence, product and process manufacturing, and related activities.
7.-Melting process:	Technologies related to glass melting, combustion engineering, energy utilization and pollution control
8.-Design and engineering linkages:	Technologies associated with equipment design and developing an effective relationship with suppliers.
9.-Customer service:	Systems to support all downstream value activities such as sales, technical customer service, channel customer relationship, advertising and, technical problems-solving for customers, and training.

One alternative to analyzing the degree of knowledge of the different STUs existing within the company, is to follow the familiar/unfamiliar matrix by Roberts and Berry (1985), where the different levels of technological familiarity can determine the type of technology strategy. Familiarity is the degree to which a technology has or has not formerly been embodied within the existing product scope or processes of the firm. Figure 4.4 illustrates the degree of familiarity for the different technologies identified in the firm.

FIGURE 4.4. Assessment of STUs Familiarity

	Core Technology	Minor Improvement	Major Enhance	New Related	New Unrelated
1.-Products characterization		●			
2.-Glass reflective processes	●				
3.-Process instrumentation			●		
4.-Fenestration technology				●	
5.-Process technologies	●				
6.-Information technology system				●	
7.-Melting process	●				
8.-Design and engineering linkages			●		
9.-Customer service		●			

Key to measure the level of familiarity:

FAMILIARITY LEVEL	DESCRIPTION
Core Technology	Used within the corporation. Embodied in products or processes. Included in the unique competencies.
Existing Minor Improvement	Used within the company. The main features relate to or overlap with existing technological skills knowledge.
Existing Major Enhancement	The base of this technology is related to knowledge existing in the company without being embodied in the product or processes, but requires a strong dedication from RD&E.
New Related	The technology has been systematically monitored from within the company in anticipation of future utilization.
New Unrelated	Is relevant and reliable and can affect new developments in product or processes. Advice available from external consultants.

Source: Adapted from Roberts and Berry (1985)

Next, the challenges from changes in the technology function should be identified and presented in the form of strategic challenges. Those challenges are:

- Increase the level of resources, knowledge, and skills in the three base technology areas, and establish an effective technology transfer plan.
- Strengthen the effort for a more effective implementation in product characterization and customer-oriented service to improve competitive position.
- Establish an integrated information technology system to improve communication, find and develop better sources of information, and tighten relationships within the organization, suppliers and market needs.
- Monitor new materials for the building industry, international construction, fenestration technology; and future uses for glass (i.e., a high performance composite incorporating electronic, holographic or other materials, that could lead to developing a new product line).

4.3 TECHNOLOGY ENVIRONMENTAL SCAN

A thorough knowledge of the intrinsic characteristics of each STU used by the company can generate the high-quality strategic thinking required for long-term technology development to ensure competitive advantage. The technology environmental scan focuses on this knowledge to derive trends and the degree of attractiveness of each technology. The final goal is to identify the key opportunities and threats that technology presents to the company. This analysis is carried out at the STU level, with all the STUs previously identified and their impact in the business strategy.

To evaluate the state of the technology and future trends, I will use the competitive impact of each technology. The competitive impact of the technology is extrinsic, closely dependent on the industry that applies it. Competitive impact indicates the difference that such advance might make to a specific business in a specific industry. Based on the planning concepts mentioned in Chapter Two (refer to Figures 2.5 & 2.6

page 40), valuable insights are gained about the benefits of each STU for VVP. Figure 4.5 shows the competitive impact of each STU.

FIGURE 4.5. Competitive Impact of Specific STUs

	PACING	KEY	BASE
1.-Products characterization		●	
2.-Glass reflective processes		●	
3.-Process instrumentation		●	
4.-Fenestration technology	●		
5.-Process technologies			●
6.-Information technology system		●	
7.-Melting process			●
8.-Design and engineering linkages		●	
9.-Customer service			●

The outcome of the environmental scan is a set of technological opportunities and threats for the company defined in terms of the STUs that support its activities. For the present case the following have been identified:

- **Technological Opportunities.**
  - STUs 5,7 and 9 (from Figure 4.5) are the based on the performance, and these should be very well-executed to maintain competitive position, excellent quality, and control costs. Customer service is the key factor to developing strong relationships and loyalty in the distribution channels.
  - STUs 1,2,3,6 and 8 are key technologies in the company, and great effort should be directed to ensuring and maintaining a competitive advantage.
  - STU 4 could has the ability to create strong differentiation within the flat glass industry. This can anticipate future market needs, building trends, and advance materials technology.

- **Technological Threats.**
  - Extra efforts to excel in technologies such as 5,7 and 9 will add technological excellence but will not add any advantage to the company.
  - The rate of incremental innovations in STUs 1,2,3, and 8 is permanent and can lead to important process improvement. Develop a closer contact with equipment suppliers as a source of possible innovations.
  - If STU 6 is not fully incorporated, there is a potential for missing a wider technology spectrum, and for lagging behind in many other relevant business activities.
  - If STU 4 remains in an embryonic phase, the route of future industrial developments will be highly uncertain. Therefore the ability to predict R&D cost and technical success is very poor, but can help to launch new business opportunities by assess the emerging technology.

4.4 TECHNOLOGY INTERNAL SCRUTINY

The internal scrutiny analysis is intended to determine the performance of the company by measuring the company's technical capabilities compared to its competitors in order to gain sustainable competitive advantage through technology. The analysis assesses the position of each specific STU in relation to the company as a whole. Therefore, we need to estimate the strengths and weaknesses of each STU relative to the company's competitors.

The goal of this analysis is to measure how good each STU is now and will be in supporting the company strategy, so, this analysis depends on a clear sense of what the company strategy is. I will employ estimates used in the concept of technological competitive position, developed by Roussel (1991), that measures the degree to which a company masters important technologies relative to its competitors. To carry out this analysis, I will estimate the strengths and weaknesses subjectively, based on personal

technical judgments, insights, and experience. Figure 4.6 shows the descriptive estimates that can be used to assess a firm's competitive technological strength.

Figure 4.6. Generalized Template for Determining Technological Competitive Position

DESCRIPTOR	CHARACTERISTICS
Dominant	-Powerful technological leader. -High commitment, funds, manpower, creativity. -Well recognized in industry. -Sets pace and direction for technological development. -Competitors consistently seek to catch up.
Strong	-Able to express independent technical action, set new directions. -Technological commitment and effectiveness consistently high. -Technological accomplishments distinguish its SBUs from lesser competitors.
Favorable	-Able to sustain the technological competitiveness of the SBU it serves. -Has strengths that can be exploited to improve technological competitive position. -Not a technological leader except in developing niches.
Tenable	-In a catch-up mode. -Unable to set independent course. -Can maintain competitiveness of SBU, but unable to differentiate it from competitors.
Weak	-Declining quality of technical output versus competitors. -Short-term, firefighting focus. -Products, processes, cost slipping relative to competitors. -Difficult but not impossible to turn around.

Source: Roussel, 1991, pp. 88.

In this context, technological competitive position is an expression of the size and ability of the technical resources to achieve a desired result. The elements used to assess the competitive technological position have been inferred from input indicators such as R&D organization, training, rate of innovation, facilities, people, etc., and from output indicators like: products, processes, performance, patents, publications, etc.

Figure 4.7 shows the technological competitive strength for each STU as applied to the VVP case.

Figure 4.7. Technological Competitive Strength of the STUs

	Dominant	Strong	Favorable	Tenable	Weak
1.-Products characterization			●		
2.-Glass reflective processes			●		
3.-Process instrumentation				●	
4.-Fenestration technology					●
5.-Process technologies		●			
6.-Information technology system				●	
7.-Melting process			●		
8.-Design and engineering linkages				●	
9.-Customer service	●				

The final outcome of this analysis is a set of strengths and weaknesses of the company with respect to technology. As a result of the internal scrutiny at the STU level, for VVP case has the following technical strengths and weaknesses are establish:

- **Technology Strengths.**
  - Dominant position in customer service, with extensive experience. Very important to sustaining market position and maintaining strong customer relationships.
  - Strong position in process technologies, being able to operate in a competitively at a high level of productivity level and low-cost manufacture.

- Favorable position in STUs 1, 2, 6 and 7 that should be used to improve technological competitive position. These are key technologies for new product development and powerful sources of information (STU 6).

- **Technology Weaknesses.**
  - STU 3. is only tenable, which means a lack of resources in this technology that could lead to process improvements.
  - A tenable position in STU 8. which plays an important role for sources of innovation and possible areas of partnership.
  - The coordination and communication of technological activities to those STUs that require RD&E, Manufacturing, and Marketing should be improved, and more effective use of information technology should be developed and applied.
  - Lack of knowledge and monitoring method for fenestration technology. Develop technical skills for future growth in this field.

Another element of the technology internal scrutiny that has been found particularly useful is to analyze the strengths and weaknesses of the firm's existing policies in each of the critical categories of decision making. Decisions that affect the way the technology enters, moves across the organization, and is incorporated into the final product or service is governed by a set of managerial policies that the company has stated or that have evolved with company culture. The taxonomy of decisions that are

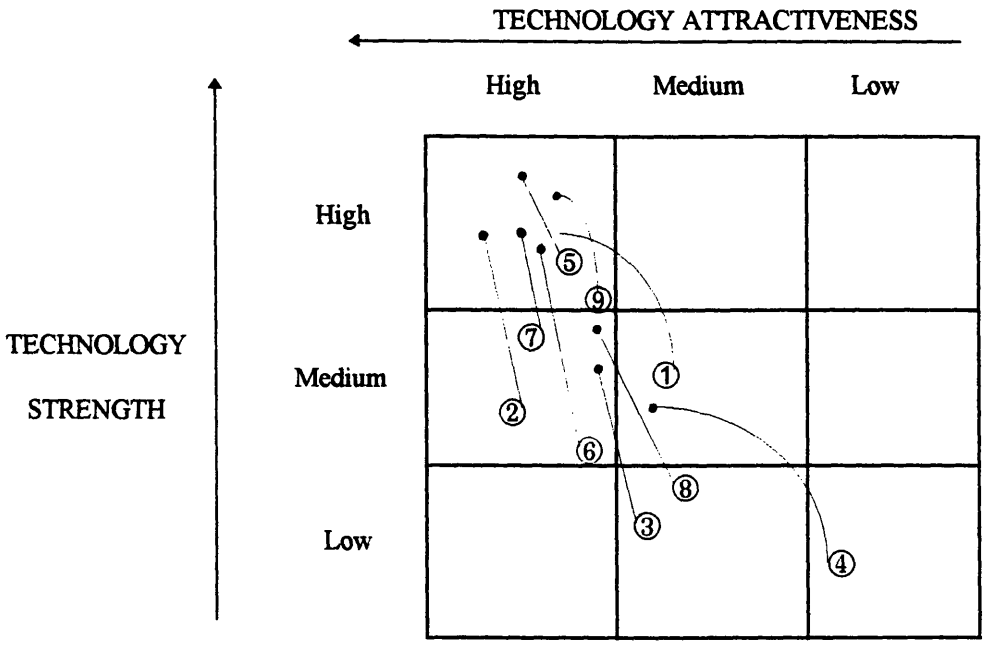
relevant to technology strategy is proposed by Hax and Majluf (1991), based on seven key categories. Due to reasons of confidentiality, I can not include this analysis, but it represents a valuable source of information for the company in assessing its the internal scrutiny.

4.5 TECHNOLOGY ATTRACTIVENESS-TECHNOLOGY STRENGTH MATRIX.

The technology attractiveness-technology strength matrix represents a useful tool for positioning the firm's STUs and proving an overall picture of the relative position of each STU. This matrix graphically displays all of the firm's STUs on two dimensions: technology attractiveness and technology strength.

This map should be drawn after completing the environmental scan and internal scrutiny and before the formulation of technology strategy. Figure 4.8 illustrates a matrix of VVP's STUs, where the circles identify the existing position of each STU, and the dots end of each line the future position. Ideally, the company would like to have all its STUs in the high-attractiveness high-strength cell of the matrix. What is crucial is to poinpoint the competitive moves that should be made in order to gain competitive strength for highly attractive STUs. The amount of effort and resources to be allocated to each STU depends both on the company's ability to gain competitive advantage, and the prospects for future attractiveness of an STU. It is important to separate the current portfolio representation from its future projection.

FIGURE 4.8. Position of the STUs in the Technology Portfolio Matrix



The current position of each STU is my subjective diagnosis of the technology attractiveness and the firm's technological competencies. The future is my own beliefs about technological trends, and the company's capacity to improve its competitive standing.

4.6 FORMULATION OF TECHNOLOGY STRATEGY

Having identified the technological requirements developed from the business strategy, and completed the analysis of the sources of information (refer to Figure 4.2) the final objective in the formulation of technology strategy is the development of a set

of action programs, and the operational commitments implicit in the technology policies. To build the action programs, the outcomes should:

- Respond to the technological requirements generated from the business strategy.
- Seize the opportunities and neutralize the threats identified in the environmental scan.
- Reinforce the strengths and eliminate the weaknesses detected in the internal scrutiny.
- Address all the issues linked to the strengthening of the technology portfolio matrix.

The following are the technology action programs developed for VVP. They should also be accompanied by specific action plans and budgets that are the basis of a full implementation. Only some of the action programs and a general idea of measurement tools have been included as an exercise due to obvious reasons of secrecy.

ACTION PROGRAM #1:

Develop a technology plan as a basic framework for generating the adequate growth in the core competencies of the SBU; evaluate technology policies to achieve a significant technological position as a source of competitive advantage.

Key indicator for management control: Gantt schedules and specific action programs.

First major milestone description: Plan description and policies, December 1995.

ACTION PROGRAM #2:

Establish strong relationships with equipment suppliers in order to extract valuable information on potential new innovations.

Key indicator for management control: Number of useful contacts and control of key information tracked, Gantt schedules.

First major milestone description: Reports with opportunities and threats and plan to evaluate key technological changes.

ACTION PROGRAM #3:

Structure a system to monitor advances in STUs 2, 3, 4, 5 and 6 to determine possible future impacts on the line of products and processes.

Key indicator for management control: Number of references tracked, Gantt schedules.

First major milestone description: Reports with opportunities and threats and the assessment of implications for those technologies.

Linkages of Technology Action Programs	Action Program Number		
	# 1	# 2	# 3
• **Technology Requirements of the Business Strategy.**			
Develop an information technology system for an effective management practice, and create a business competitive advantage.	■		■
Set the appropriate tools for technology transfer and assimilation process among the RD&Engineering, Manufacturing, and Marketing operations.	■		
Enhance and develop the core technologies needed for reflective glass processes and the introduction of new products.	■		■
Assess the long-term performance requirements for the use of glass as an integrated system in the construction industry (fenestration, facades, etc.) for glazing, and the needs of glass cleaning media.			■
Improve manufacturing capabilities to increase productivity and ensure performance as a low-cost manufacturer; promote personnel commitment and ownership.	■		

	Action Program Number		
	# 1	# 2	# 3
• Challenges from Changes in the Technology Function.			
Increase the level of resources, knowledge, and skills in the three base technology areas, and establish an effective technology transfer plan.	■		
Strengthen the effort for a more effective implementation in product characterization and customer-oriented service to improve competitive position.			■
Establish an integrated information technology system to improve communication, find and develop better sources of information, and tighten relationships within the organization, suppliers and market needs.	■	■	
Monitor new materials for the building industry, international construction, fenestration technology; and future uses for glass (i.e., a high performance composite incorporating electronic, holographic or other materials, that could lead to developing a new product line).	■	■	
• Technological Opportunities.			
STUs 5,7 and 9 are based on performance, and these should be very well executed to maintain competitive position, excellent quality, and control costs. Customer service is the key factor to developing strong relationships and loyalty in the distribution channels.	■		
STUs 1,2,3,6 and 8 are key technologies in the company, and great effort should be directed to ensuring and maintaining a competitive advantage.			■
STU 4 has the ability to create strong differentiation within the flat glass industry. This can anticipate future market needs, building trends, and advance materials technology.	■	■	
• Technological Threats.			
Extra efforts to excel in technologies such as 5,7 and 9 will add technological excellence but will not add any advantage to the company		■	
The rate of incremental innovations in STUs 1,2,3, and 8 is permanent and can lead to important process improvement. Develop a close contact with equipment suppliers is another source of		■	
If STU 6 is not fully incorporated, there is a potential for missing a wider technology spectrum, and for lagging behind in many other relevant business activities.	■		
If STU 4 remains in an embryonic phase, and the route of future industrial developments will be highly uncertain. Therefore the ability to predict R&D cost and technical success is very poor, but can help to launch new business opportunities (emerging tech.)	■		

	Action Program Number		
	# 1	# 2	# 3
• **Technology Strengths.**			
Dominant position in customer service, with extensive experience. Very important to sustaining market position and maintaining strong customer relationships.			■
Strong position in process technologies, being able to operate competitively at a high level of productivity level and low-cost manufacture.			■
Favorable position in STUs 1, 2, 6 and 7 that should be used to improve technological competitive position. These are key technologies for new product development and powerful sources of information (STU 6).	■		■
• **Technology Weaknesses.**			
STU 3 is only tenable, which means a lack of resources in this technology that could lead to process improvements.	■		■
A Tenable position in STU 8, which plays an important role for sources of innovation and possible areas of partnership.	■	■	
The coordination and communication of technological activities to those STUs that require RD&E, Manufacturing, and Marketing should be improved, and more effective use of information technology should be applied.	■		■
Lack of knowledge and monitoring method for fenestration technology. Develop technical skills for future growth in this field.	■		■

The methodology ensure an appropriate diagnosis of the existing state of the technology utilization and to reflect on the necessary changes to be made in order to make technology more effective as a source of competitive advantage.

CHAPTER FIVE

CONCLUSIONS AND REFLECTIONS

The conclusions and reflections presented here are based on information gathered on the flat glass industry as well as the outcomes presented for the business and technology strategy. The author recognizes there has been a bias throughout this study due to his technical background and time involved in this industry. Nevertheless, the methodology suggested by Hax and Majluf (1991), and used for the business and technology strategy, has enabled the study to be addressed in a systematic form.

Overall the methodology has worked quite well, and the following reflections were obtained from applying it to the analysis done for Vitro Vidrio Plano in the glass manufacturing business unit:

- The idea of using technological requirements, which are derived from the business strategy. help greatly in focusing attention on opportunities as well as to elaborate on greater detail how well the company is using a specific technology. Nevertheless, as technology is a very diffuse function, it is very important to carry out the step of reviewing policies in technology management, viewing technology as a whole.
- The methodology suggested, helps to create the clear concept that technology is much more than just R&D or licensing; it is a more diffuse and dilute tool that companies can use to create a sustainable competitive advantage. If it is not managed effectively, serious problems will occur in the long run.
- Assessing the technology and innovation trends before defining the business mission helps to facilitate discussions in the following steps of the framework, particularly in the environmental scan and internal scrutiny at the business and technology levels.
- The planning concepts proposed by Roussel, Saad, and Erickson (1991) complemented and augmented the development of the technology strategy while following the basic framework suggested by Hax and Majluf. Those concepts

addressed the critical role of the Business/R&D partnership in ensuring the profitability and balanced portfolio of R&D in today's competitive environment.

The basic framework used in the business strategy has the ability to guide the strategic planning process so that all relevant elements are covered. According to the analysis performed in Chapter Three, one significant outcome is the mission statement of the business unit, which in VVP's case is:

> **The VVP Division is devoted to manufacturing flat glass products of superior quality and value to customers based on the traditional principles of integrity, with world-class excellence, and recognized as the best choice. To satisfy the needs of evolving demands, and thoroughly understand the profitability of the current product line, VVP is committed to expanding its present domestic and international markets, while diverse considering market opportunities. Its purpose is achieved through an organization driven by a devoted management team, excellence, and a spirit of continuous improvement.**

This thesis also used the results of the environmental scan and internal scrutiny to derive the positioning of the strategic business unit (SBU) in the Industry Attractiveness-Business Strength Matrix, where the generic resulting strategies are: ***"Identify growth segments, invest strongly, maintain position elsewhere".*** The business strategic priorities are: ***"The business has a good position in an industry that is getting less attractive (commodity), but there are situations to exploit".***

The outcome of this analysis was six broad action programs that defined the main tasks that VVP must carry out at the business level. In developing the technology strategy using the Hax/Majluf basic framework allow to:

- Assure proper linkage between the business and technology strategies.
- Perform an environmental scan to detect the major opportunities and threats affecting the technology function.

- Conduct a strategic audit to detect the strengths and weaknesses associated with the technology function.
- Work in a more structured, formal, and efficient way to manage the information and to develop a common understanding among the management of the company with regard to those technologies that are relevant for the accomplishment of the business mission.

The final outcome of this analysis has been a set of action programs that cover:

- The technological requirements of the business strategy.
- The challenges from changes in the technology function.
- The technology opportunities and threats.
- The technology strengths and weaknesses.

These action programs ensure appropriate changes of the technology in order to make it more effective as a source of competitive advantage. My own view is to address in the technology plan, the effective integration of the information technology system as an important facilitator in the innovation process effort, creating a more empowered and diversified workforce oriented toward customer service, being a low-cost producer, and improving new product and process development by fostering personnel commitment and ownership. This imply changes in business process, organizational structure and culture, that must be adapted in order to be truly effective.

The Dynamics of innovation process implies the understanding of the relationship between product and process change over time. In nonassembled products such as glass, process innovation become the driven force for technological changes. The technology maturity cycle, should be connected with R&D activities and strategy, since the mission of the business typically changes as a function of the maturity cycle. Nevertheless the real challenge in innovation and technology management lies in the ability to trigger, generate, control and steer new ideas through the maze. An effective plan for technology transfer and assimilation process, the understanding of future requirements in fenestration technology, the information technology system as industrial intelligence,

technologies related to glass surface chemistry, and systems to support the downstream value activities for customer service are crucial technological functions.

It has been demonstrated in other studies using this methodology that the best way to create valuable insights regarding business opportunities and technology strategy is through a well-implemented workshop. The constructive discussion generated at such workshop has been demonstrated to be a central tool of the methodology.

Finally, my overall reflection is that the methodology used in this thesis has the power to drive the process so as to cover any subject that is relevant for the strategic planning. But at the same time, I believe its major strength is its ability to promote communication and interaction among top management in order to achieve consensus and create common views of the company, as well as present and future challenges for developing a competitive technology profile in order to achieve a superior competitive performance, which are considered truly relevant and leads to a collective enrichment of their business understanding.

"Perceptive managers recognize that competition is not exclusively a battle between the large and the small, or the well resourced versus the impoverished, all playing by the same set of rules. Competition is also a contest among strategies. .....-Strategic innovation means how to adopt a creative and novel approach to compete-".

Baden-Fuller and Stopford (1994)

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